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EXPERIMENTS

ON

THE FAN BLAST,

BY

WILLIAM BUCKLE.

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EXPERIMENTS ON THE FAN BLAST.

BY MR. WILLIAM BUCKLE, OF BIRMINGHAM.

The present paper has reference to a portion of a series of Experiments on the Fan Blast,—a subject which many members of this Institution are conversant with; but it is hoped that the hints here thrown out may be serviceable in leading to such constructions of the fan as shall ensure the greatest useful effect with the least expenditure of power. The fan has become an indispensable machine in smithies and foundries; it abridges time and labour, and is otherwise a great improvement over the old system of bellows. The puffy blasts of the latter admit of no comparison with the uniform stream obtained by the fan. By means of the fan the smith can heat his work with precision, can vary at discretion the size of his nozzle tuyere, without deteriorating the density of his blast; and can conveniently heat one piece of work while shaping another.

In a well regulated smithy, the main pipe from the fan is furnished with an air chest and with nozzle pipes varying from 1 to 3 inches diameter. The pressure of the blast is made to range from 4 to 5 ounces per square inch. A nozzle pipe of 1⅝ inch diameter is found a suitable size for general engine forgings.

The position of the fan in its chest, that is preferred and generally adopted, is an eccentric position. The continually increasing winding passage between the tips of the vanes and the chest serves to receive the air from every point of the circumference of the fan, and produces a general accumulating stream of air to the exit pipe. The particles of air having passed the inlet opening, and entering on the heel of the vane, would retain the same circular path, were it not for the centrifugal force of the air due to its weight and velocity impelling them forward towards the tips of the vanes, and this continued action is going on, particle following particle, till they are ultimately thrown against the fan chest, and are impelled forward to the exit pipe. It is by this centrifugal action that the air becomes impelled and accumulated into one general stream. But, as will be presently shown,

there is a certain velocity of the tips of the vanes which best suits this action.

An ordinary eccentric-placed fan, 4 feet diameter, with vanes 10 inches wide and 14 inches long, and making 870 revolutions per minute, will supply air at a density of 4 ounces per square inch, to 40 tuyeres, each being $1\frac{5}{8}$ inch diameter, without any falling off in density. The experiments herein detailed were made with a fan 3 feet $10\frac{13}{16}$ inches diameter, the width of the vanes being $10\frac{3}{4}$ and the length 14 inches; the eccentricity of the fan $1\frac{7}{16}$ inches, with reference to the fan case, the number of vanes being 5, and placed at an angle of 6° to the plane of the diameter; the inlet openings on the sides of the fan chest $17\frac{1}{2}$ inches diameter, the outlet opening 12 inches square; the space between the tips of the vanes and the chest increasing from $\frac{3}{8}$ inch over the exit pipe to $3\frac{1}{2}$ inches at the bottom at a point perpendicularly under the centre. To the blast pipe leading to the tuyeres a slide valve was attached, by means of which the area of the discharge was accurately adjusted to suit the required density.

These experiments were made with a view to ascertain what density or pressure of air could be obtained, with the vanes moving at given velocities, the outlet pipe being closed; and also at given velocities, with the outlet open, but its area varied at discretion; and further, to ascertain the horse power required to drive the fan under these several conditions.

The gauge to indicate the density or pressure of the air was a glass graduated tube, primed with water, it being more sensitive and having a greater range than the mercurial one.

The horse power was ascertained by an indicator, the friction of engine and gearing being deducted in each experiment. With reference to the term Theoretical Velocity, as used in the table, it may be necessary to observe, that by this is meant the velocity which a body would acquire in falling the height of a homogeneous column of air equivalent to the required density. Having given the above preliminary explanations, we come to the experiments as recorded in the following table.

The 1st column is the number of the experiment.

The 2nd is the number of revolutions of the fan per minute.

The 3rd is the velocity of the tips of the vanes in feet per second.

The 4th is the density or pressure of the air in ounces per square inch, as indicated by the gauge.

The 5th is the height in inches of a column of mercury equivalent to the density.

The 6th is the height in feet of a column of air equivalent to the density.

The 7th is the area of the discharge pipe in square inches.

The 8th is the indicated horse power.

The 9th is the theoretical velocity of the air in feet per second.

The 10th is $\frac{9}{10}$ths of the theoretical velocity of the air in feet per second.

The 11th is the theoretical quantity of air discharged in cubic feet per second.

The 12th is the centrifugal force of the air per square inch, calculated from the theoretical velocity.

By this paper it is intended to show that there are certain velocities with which the tips of the vanes of a fan should move, according to the required density of air, and that there are certain laws which govern these velocities.

Water is 827 times heavier than air, and mercury is 13·5 times heavier than water; consequently mercury is 11164 times heavier than air. A column of mercury one inch in height would therefore balance a column of air 11164 inches or 930·3 feet in height.

A column of mercury 30 inches in height produces a pressure of 15 lbs. per square inch; hence a column of mercury 1 inch in height gives a pressure of $\frac{1}{2}$ lb. or 8 ounces per square inch; and therefore a column of mercury $\frac{1}{8}$ inch in height will give a pressure of 1 ounce per square inch. Consequently the height in inches of a column of mercury equivalent to any given pressure or density is found by dividing the density in ounces per square inch by 8.

Let A be the height in inches of a column of mercury equal to any given density, and let B represent 930·3, and C 64*; then $\sqrt{(A \times B \times C)} = \sqrt{(A \times 930{\cdot}3 \times 64)} = V =$ the velocity that a body would acquire in falling the height of a column of air equivalent to the density.

The centrifugal force of air coincides with the results obtained by the laws of falling bodies, that is when the velocity is the same as the velocity which a body will acquire in falling the height of a

* The space which a gravitating body will pass through in one second is $16\frac{1}{12}$ feet; but by the principle of accelerating forces, the velocity of a falling body in one second is equal to twice the space through which it has passed in that time, or the velocity in any given time is equal to the square root of the number obtained by multiplying 64 by the height in feet.

TABLE OF EXPERIMENTS.

1	2	3	4	5	6	7	8	9	10	11	12
No. of Experiments.	Number of Revolutions of Fan per Minute.	Velocity of Tips of Vanes in Feet per Second.	Density of Air in Ounces per Square Inch.	Height of Mercury in Inches equivalent to Density.	Height of Column of Air in Feet equivalent to Density.	Area of Discharge Pipe in square Inches.	Indicated Horse Power.	Theoretical Velocity of Air in Feet per Second. *	9-10ths of Theoretical Velocity of Air in Feet per Second. *	Theoretical Quantity of Air discharged in cubic Feet per Second.	Density of Air calculated by Laws of Centrifugal Force in ounces per square Inch.
No. 1	1160·0	236·80	9·40	1·18	1093·10	0	9·60	264·40	237·96	0	9·30
2	1081·7	220·80	7·90	0·99	918·20	0	7·54	242·40	217·80	0	7·80
3	1000·0	204·16	6·90	0·86	801·91	0	6·68	226·50	203·85	0	6·80
4	907·5	185·28	5·60	0·70	651·21	0	5·36	204·10	183·69	0	5·50
5	840·0	171·50	4·50	0·56	522·80	0	3·82	182·90	164·61	0	4·40
6	705·8	144·10	3·50	0·44	406·50	0	2·21	161·20	145·08	0	3·40
Fan discharging Air at a Density of SEVEN Ounces per square Inch.											
7	1086·6	221·80	7·00	0·88	814·01	37·50	13·31	228·24	205·40	59·40	6·92
8	1063·3	217·09	7·00	0·88	814·01	38·13	11·02	228·24	205·40	60·40	6·92
Fan discharging Air at a Density of SIX Ounces per square Inch.											
9	1086·6	221·80	6·00	0·75	697·72	48·75	13·81	211·30	190·17	71·50	5·93
10	1045·0	213·30	6·00	0·75	697·72	53·13	12·54	211·30	190·17	77·91	5·93
11	941·6	192·20	6·00	0·75	697·72	24·38	6·43	211·30	190·17	35·71	5·93
Fan discharging Air a Density of FIVE Ounces per square Inch.											
12	1086·6	221·80	5·00	0·63	581·43	60·00	14·26	192·90	173·61	80·37	4·94
13	1035·8	211·48	5·00	0·63	581·43	65·00	13·05	192·90	173·61	87·00	4·94
14	950·0	193·90	5·00	0·63	581·43	52·50	8·75	192·90	173·61	70·32	4·94
15	855·0	174·50	5·00	0·63	581·43	22·50	4·53	192·90	173·61	30·00	4·94

Fan discharging Air at a Density of FOUR Ounces per square Inch.											
16	1086·6	221·80	4·00	0·50	465·10	69·00	14·19	172·50	155·25	82·65	3·95
17	1035·8	211·48	4·00	0·50	465·10	75·00	13·33	172·50	155·25	89·84	3·95
18	966·7	196·68	4·00	0·50	465·10	65·62	9·53	172·50	155·25	78·60	3·95
19	870·0	177·62	4·00	0·50	465·10	78·13	11·32	172·50	155·25	93·58	3·95
20	760·0	155·16	4·00	0·50	465·10	33·13	3·30	172·50	155·25	38·98	3·95
Fan discharging Air at a Density of THREE Ounces per square Inch.											
21	983·3	200·70	3·00	0·38	348·86	82·68	10·15	150·00	135·00	86·00	2·94
22	855·0	174·50	3·00	0·38	348·86	102·72	10·61	150·00	135·00	117·10	2·94
23	773·3	157·80	3·00	0·38	348·86	89·63	7·56	150·00	135·00	93·33	2·94
24	659·2	134·50	3·00	0·38	348·86	56·25	2·98	150·00	135·00	58·50	2·94
Fan discharging Air at a Density from TWO to ONE Ounce per square Inch.											
25	786·7	160·50	2·00	0·25	232·50	151·60	9·10	122·00	109·80	128·40	1·98
26	676·6	138·15	2·00	0·25	232·50	124·13	5·89	122·00	109·80	107·24	1·98
27	760·0	155·16	1·00	0·13	116·28	264·90	9·38	86·26	77·63	158·60	0·98
28	676·6	138·15	1·00	0·13	116·28	264·90	7·27	86·26	77·63	158·60	0·98
Fan discharging Air at various Densities.											
29	1166·7	238·10	8·75	1·09	1016·81	13·75	11·94	254·75	229·27	24·32	8·62
30	1160·0	236·80	8·50	1·06	987·97	16·25	11·90	251·20	226.08	28·34	8·40
31	1140·0	232·70	8·00	1·00	930·30	22·50	12·36	244·00	219·60	38·12	7·91
32	855·0	174·50	2·40	0·30	279·09	126·30	10·61	133·60	120·24	117·10	2·36

* These figures in the first six experiments are merely inserted to show the Velocity due to the Density of the Air; and to allow of a comparison being made with the real Velocity of the Tips of the Vanes, without having recourse to calculations.

Note.—In calculating the cubic quantity of Air discharged per second, (as shewn in column 11.) no allowance has been made for the friction of the Air against the sides of the pipes and apertures.

homogeneous column of air equivalent to any given density, as is shown by the table (column 12). Here the velocity has been taken as obtained from the laws of falling bodies (as in column 9), to find the centrifugal force or density of the air. To do this, apply the following rule.

Having given the velocity of the air and the diameter of the fan, to ascertain the centrifugal force :—

Rule.—Divide the velocity in feet per second by 4·01, and again divide the square of the quotient by the diameter of the fan in feet. This last quotient multiplied by 1·209, the weight in ounces of a cubic foot of air at 60° Fahrenheit, is equal to the centrifugal force in ounces per square foot, which divided by 144 is equal to the density of the air in ounces per square inch.

Thus if D be the density of the air in ounces per square inch, V the velocity of the tips of the vanes in feet per second, and d the diameter of the fan in feet :—

$$D = \left(\frac{V}{4{\cdot}01}\right)^2 \times \frac{1{\cdot}209}{d} \times \frac{1}{144}$$

Or the following formula may be substituted :—

$$D = NV \times {\cdot}0000273$$

where D is the density of the air in ounces per square inch, N the number of revolutions of the fan per minute, and V the velocity of the tips of the vanes in feet per second.*

* The two formulæ for D given above are obtained as follows :—

Taking the centrifugal force of a cubic foot of air at the tips of the vanes considered as a solid body,

$$D = \frac{v^2}{r} \times \frac{w}{g} \times \frac{1}{144}$$

where D = pressure or density of air in ounces per square inch, v = velocity of tips of vanes in feet per second, r = radius of fan in feet, w = weight in ounces of 1 cubic foot of air = 1·209, and g = force of gravity = 32·2 ;

$$\text{therefore } D = \frac{v^2}{r} \times \frac{1{\cdot}209}{32{\cdot}2} \times \frac{1}{144}$$

or if d be the diameter of the fan in feet, then $d = 2r$, and

$$D = \frac{v^2}{d} \times \frac{1{\cdot}209}{16{\cdot}1} \times \frac{1}{144}$$

$$\text{or } D = \left(\frac{v}{4{\cdot}01}\right)^2 \times \frac{1{\cdot}209}{d} \times \frac{1}{144}$$

which agrees with the first of the two formulæ.

Let us now examine the results of the table, considering first the velocity of the tips of the vanes, and the power necessary to drive the fan. In experiments, Nos. 1, 2, 3, 4, 5, and 6, we find by inspecting the table the velocities 236·80, 220·80, 204·16, 185·28, 171·50, and 144·10 respectively, and the corresponding densities of the air are 9·40, 7·90, 6·90, 5·60, 4·50, and 3·50 ounces per square inch respectively. The fan, it must be understood, is discharging no air, but its velocity is merely keeping the air at a certain density or pressure per square inch. Under these circumstances, it requires a certain velocity of the tips of the vanes to maintain a certain density of air, but not in a simple ratio.

The law which governs the velocity of the tips of the vanes appears from these experiments to be that the tips of the vanes should move with $\frac{9}{10}$ths of the velocity a body would acquire in falling the height of a homogeneous column of air equivalent to the density. The latter has been called in the table the theoretical velocity, and by comparing Nos. 1, 2, 3, 4, 5, and 6 experiments as above, the velocity of the tips of the vanes will be found to agree pretty nearly with $\frac{9}{10}$ths of the theoretical velocity. Thus, if the velocity of the tips of the vanes be represented by 1·000, then $\frac{9}{10}$ths of the theoretical velocity will be represented by

	1·005	in No.	1	experiment,
	·986	„	2	„
	·999	„	3	„
	·992	„	4	„
	·960	„	5	„
	1·007	„	6	„
The mean......	·992			

But it will be found not only that $\frac{9}{10}$ths of the theoretical velocity is the most effective speed when the fan is not discharging air, but that the same proportion holds good also when the outlet pipe is open; that is, that the maximum effect of the fan is when the vanes move with a

---

Also if n be the number of revolutions of the fan per minute, $n = \frac{v \times 60}{\text{circumference}} = \frac{v \times 60}{d \times 3{\cdot}1416}$

and as before, $D = \frac{v^2}{d} \times \frac{1{\cdot}209}{16{\cdot}1} \times \frac{1}{144}$;

therefore $D = \frac{v \times 60}{d \times 3{\cdot}1416} \times v \times \frac{3{\cdot}1416}{60} \times \frac{1{\cdot}209}{16{\cdot}1} \times \frac{1}{144}$

or $D = nv \times {\cdot}0000273$, which is the second of the two formulæ given above.

velocity ranging from the theoretical velocity due to the density of the air to $\frac{9}{10}$ths of that velocity, the greatest quantity of air being discharged by the fan under these conditions with the least expenditure of power. To illustrate this more fully, let us refer to the table of experiments, and for our examples we will take Nos. 9, 10, and 11; here the density in each case is 6 ounces.

In No. 10 experiment the velocity of the tips of the vanes is 213·30 feet per second, while the theoretical velocity is 211·30 feet per second, being nearly the same. The quantity of air discharged is 77·91 cubic feet per second, and the power employed in this case amounts to 12·54 horse power.

In No. 11 experiment the velocity of the tips of the vanes is 192·20 feet per second, and $\frac{9}{10}$ths of the theoretical velocity 190·17 feet per second. Now, in these two experiments the results are in proportion to each other nearly; in No. 11 the quantity of air discharged amounts to 35·71 cubic feet per second, and takes 6·43 horse power, while in No. 10 the discharge is 77·91 cubic feet per second, and takes 12·54 horse power. Thus the discharge of air is nearly 2 to 1, and the horse power employed in the same proportion.

In No. 9 experiment the velocity of the tips of the vanes is 221·80 feet per second, being 10 feet per second more than the theoretical velocity; the cubic feet discharged per second being 71·50, and the power 13·81 horse power. Now, if we compare this with No. 10 experiment, we shall find that the velocity is 10 feet per second more, and the cubic feet discharged 6 less, and the horse power 1·3 more.

In the following examples we shall call the theoretical velocity per second unity, beginning with No. 15 experiment. In this example, and similarly afterwards, we shall also call the quantity of air discharged in cubic feet per second unity, and also the horse power. The density of the air in the four following experiments is 5 ounces per square inch:—

No.	Theoretical Velocity.	Velocity of tips of vanes.	Quantity discharged.	Horse power.
15	1·00	0·91	1·00	1·00
14	1·00	1·01	2·34	1·93
13	1·00	1·10	2·90	2·88
12	1·00	1·15	2·67	3·16

In the five following experiments the density is 4 ounces per square inch :—

No.	Theoretical Velocity.	Velocity of tips of vanes.	Quantity discharged.	Horse power.
20	1·00	0·90	1·00	1·00
19	1·00	1·03	2·40	3·42
18	1·00	1·13	2·02	2·89
17	1·00	1·23	2·30	4·04
16	1·00	1·28	2·12	4·27

In the three following experiments the density is 6 ounces per square inch :—

No.	Theoretical Velocity.	Velocity of tips of vanes.	Quantity discharged.	Horse power.
11	1·00	0·91	1·00	1·00
10	1·00	1·01	2·18	1·95
9	1·00	1·05	2·00	2·15

In the four following experiments the density is 3 ounces per square inch :—

No.	Theoretical Velocity.	Velocity of tips of vanes.	Quantity discharged.	Horse power.
24	1·00	0·90	1·00	1·00
23	1·00	1·05	1·59	2·53
22	1·00	1·16	2·00	3·56
21	1·00	1·34	1·47	3·40

To give further illustration of this part of our subject, we will take Nos. 7, 9, 12, and 16 experiments. Here the velocity of the tips of the vanes is the same, and will therefore be denoted by unity. The corresponding densities being 7, 6, 5, and 4 ounces, we shall call the highest unity, as also with the quantity discharged, and the horse power.

No.	Theoretical Velocity.	Velocity of tips of vanes.	Quantity discharged.	Density.	Horse power.
7	1·03	1·00	1·00	1·00	1·00
9	0·95	1·00	1·20	0·86	1·03
12	0·87	1·00	1·35	0·71	1·06
16	0·78	1·00	1·40	0·57	1·11

Nearly all the preceding examples justify our conclusion, that the greatest results are obtained when the theoretical velocity and the velocity of the tips of the vanes are nearly equal. It is evident also

that if we increase the velocity of the tips of the vanes, and only double the cubic quantity of air delivered, it must take more than double the expenditure of power, the density of the air remaining the same.

We shall now give examples of the data dictated by our table of experiments. And first, having given the density of the air, to determine the velocity of the tips of the vanes; also the horse power requisite to drive the fan under these circumstances, the fan not discharging air, but its velocity merely keeping the air at a certain density.

Let D denote the density of the air in ounces per square inch, and A the height in inches of a column of mercury equivalent to that density. Then by the laws of falling bodies (see page 5), $\sqrt{(A \times 930{\cdot}3 \times 64)} = N =$ the velocity acquired by a body falling the height of a column of air of the corresponding density.

Then $\dfrac{38 \times D}{16} = P$ the number of pounds acting on the vanes;

and $\dfrac{\frac{9}{10}\text{ths of } V \times 60 \times P}{33000} = HP$ the horse power required.

The constant number 38 is the result of experiment, and has been obtained by inserting the ascertained values of the horse power, &c., in the following formulæ, which are the converse of the preceding :—

$$\frac{HP \times 33000}{\frac{9}{10}\text{th of } V \times 60} = P, \text{ and then } \frac{P \times 16}{D} = 38.$$

Example.—Let $D = 9{\cdot}40$ ounces per square inch; then $A = 1{\cdot}175$ inches of mercury (see page 5); to determine the velocity of the tips of the vanes, and also the horse power.

Here $\sqrt{(1{\cdot}175 \times 930{\cdot}3 \times 64)} = 264{\cdot}4 = V =$ the theoretical velocity, $\frac{9}{10}$ths of which $= 237{\cdot}96 =$ the velocity of the tips of the vanes in feet per second. Then $\dfrac{38 \times 9{\cdot}40}{16} = 22{\cdot}32 = P =$ the pounds acting on the vanes of the fan. And $\dfrac{237{\cdot}96 \times 60 \times 22{\cdot}32}{33000} = 9{\cdot}6 = HP =$ the horse power required.

Having given the velocity of the air in feet per second (or, as it has been termed, the theoretical velocity), to determine the density of the air in accordance with the laws of centrifugal force.

Example.—Let the velocity be 264·4 feet per second, and the diameter of the fan 3·9 feet. Then, by a former rule (see page 8) we have $\frac{264{\cdot}4}{4{\cdot}01} = 65{\cdot}9$ and $\frac{65{\cdot}9^2}{3{\cdot}9} = 1113{\cdot}6$ and $\frac{1113{\cdot}6 \times 1{\cdot}209}{144} = 9{\cdot}34$ ounces per square inch = the density required.

Or, by the second rule, the number of revolutions per minute = $\frac{\text{velocity} \times 60}{\text{circumference}} = \frac{264{\cdot}4 \times 60}{3{\cdot}9 \times 3{\cdot}1416} = 1294{\cdot}8 = N$; and $NV \times {\cdot}0000273 = 1294{\cdot}8 \times 264{\cdot}4 \times {\cdot}0000273 = 9{\cdot}34$ ounces per square inch, as before.

To determine the horse power necessary to drive the fan when discharging air, the velocity of the tips of the vanes not exceeding $\frac{9}{10}$ths of the theoretical velocity; having given the density of air required, and the quantity to be discharged per minute.

It must here be remarked that according to the table of experiments, when the tips of the vanes move at $\frac{9}{10}$ths of the theoretical velocity, not more than 480 pounds of air are discharged per minute; but this is without any attenuation in the density.

First, find the horse power, as in the previous example, when the fan is not discharging air.

Secondly, multiply the weight of air in pounds to be discharged by the fan per minute by $\frac{9}{10}$ths of the theoretical velocity in feet per second, and divide by 33000. The quotient will give the horse power necessary to discharge this quantity of air, which add to the horse power necessary to drive the fan when not discharging air, for the answer required.

Example.—Let D be the density of air required = 4·00 ounces per square inch; then A = the height in inches of a column of mercury equal to the density = ·5 (see page 5); and let the weight of air to be discharged per minute = 220 pounds.

Here $\sqrt{({\cdot}5 \times 930{\cdot}3 \times 64)} = 172{\cdot}5$ = the theoretical velocity, $\frac{9}{10}$ths of which = 155·25 = the velocity of the tips of the vanes in feet per second. Then $\frac{38 \times 4{\cdot}00}{16} = 9{\cdot}5 = P$ = the pounds acting on the vanes of the fan. And $\frac{155{\cdot}25 \times 60 \times 9{\cdot}5}{33{\cdot}000} = 2{\cdot}67$ horse power necessary to drive the fan without efflux.

Secondly, $\frac{220 \times 155 \cdot 25}{33000} = 1 \cdot 00$ horse power necessary to discharge the given weight of air.

Then $1 \cdot 00 \times 2 \cdot 67 = 3 \cdot 67 =$ the total horse power required.

If the quantity of air to be discharged per minute be given in cubic feet, these must be converted into pounds before the above rules can be applied. Thus, let the quantity to be discharged be 2864 cubic feet per minute, at a density of 4·00 ounces per square inch. Now, a cubic foot of common air at 60° Fahrenheit weighs 1·209 ounces, therefore a cubic foot of the given density will weigh 1·229 ounces, and therefore the weight of 2864 cubic feet is 3520 ounces = 220 pounds.

When the velocity of the tips of the vanes is to be equal to the theoretical velocity, then we proceed as in the last example, taking the weight of air in pounds to be discharged by the fan per minute.

It should here be again remarked that when the fan is moving at this velocity, it is capable of discharging 480 pounds of air per minute without any falling off in density.

In a recent set of experiments the inlet openings in the sides of the fan chest were contracted from 17½ inches, the original diameter, to 12 and 6 inches diameter, when the following results were obtained:—

First, the power expended with the opening contracted to 12 inches diameter was as 2½ to 1 compared with that expended with the opening of 17½ inches diameter; the velocity of the fan being nearly the same, as also the quantity and density of air delivered.

Second, the power expended with the opening contracted to 6 inches diameter was as 2½ to 1 compared with that expended with the opening of 17½ inches diameter; the velocity of the fan being nearly the same, and also the area of the efflux pipe, but the density of the air decreased one fourth.

These experiments show that the inlet openings must be made of sufficient size, that the air may have a free and uninterrupted passage to the vanes of the fan, for if we impede this passage we do so at the expense of power.

In conclusion, time alone prevents a further investigation of this subject, but the writer hopes to return to it at no distant period, and generalize the facts gleaned from experiments.

Soho, April 26, 1847.

EXPERIMENTS ON THE FAN BLAST.

[SUPPLEMENTARY PAPER.]

In resuming the subject of the Fan Blast, I shall endeavour, as far as I conveniently can, to avoid detailed statements of the pneumatic laws involved in its consideration, as they would occupy more time than would be consistent with the present occasion; and shall proceed to remark on the most important points connected with the construction of the fan, namely, the forms and proportions which will ensure the best results, with the least expenditure of power, and will effect a diminution of the intolerable noise that generally arises from the working of the fan. And although I have not been able to carry out such leading principles to the fullest extent, I trust that I have furnished materials that will be found of value to those members whose greater leisure may enable them to do so.

From an examination of the action and apparent effect of that very useful apparatus, the blowing fan, it would appear that the air in the fan case is impelled by the vanes along the delivery pipe or channel to the chest provided for the blast; and that the continuous rapid motion of the vanes compresses the air in the pipe and chest, to a degree that may be shown and accurately measured by a water or mercurial gauge attached to the blast chest.

In the former paper the principal investigation rested on the theoretical question, whether the tips of the vanes should partake of the same velocity as a body falling freely from a certain height, the height being governed by the density of air required. Recent experiments, the results of which accompany this paper, justify the conclusions then made, as will be seen on examining tables Nos. 2, 3, and 4.

Having satisfied myself with respect to the velocity a fan ought to have, when a certain density of air is required, I propose in this paper to examine the fan under other conditions, the object being to establish the best proportions of the inlet openings in the sides of the fan chest, and the suitable corresponding length of the vanes. For this purpose,

I caused the openings in the sides of the fan chest to be made of a large diameter, and I was enabled to vary these openings, by fitting in rings of wood; and I varied the fan by attaching to its arms vanes of corresponding lengths. The experiments are classed in the tables appended :—

Table No. 1, Contains the original set of experiments given in the former paper.
„ „ 2, Experiments made with an inlet opening 30 inches diameter, the length of the vanes being reduced to 8 inches.
„ „ 3, With an inlet opening 24¾ inches diameter, the length of the vanes being 11 inches.
„ „ 4, With an inlet opening 20⅛ inches diameter, the length of the vanes being 13⅜ inches.
„ „ 1 *a*, Shows the effect produced by narrowing the vanes to 6 inches, the length being 16 inches, with outlet to delivery pipe 4 inches deep.
„ „ 2 *a*, 3 *a*, and 4 *a*, Are experiments showing the effect produced by contracting the outlet opening; the inlet opening and the length of vanes being the same as in the table under which they are classed.

In the concluding part of the former paper it was stated that by impeding the free admission of air to the vanes a loss of power was occasioned. Thus, by contracting the inlet opening to 12 inches diameter, more than twice the power was expended. This led to an extension of the openings, the results of which will be seen on comparing the former state of the fan, as shown in table No. 1, with the present state, as shown in tables Nos. 2, 3, and 4.

In the first five experiments, no efflux of air takes place; and if, in these experiments, we take the means of the density of the air and of the horse power, and call them unity, their proportions to the means of the corresponding experiments in tables 2, 3, and 4, will stand thus :—

No. of Table.	Density of Air.	Horse power.
1	1·00	1·00
2	0·69	1·21
3	0·80	0·90
4	1·00	1·10

Here the results are in favour of the fan in its original shape, and similar results appear when the fan is discharging air.

I will now proceed to consider the diameter of the inlet opening, and the best length of vane.

From the experiments given in the tables it will be seen that the longer vane possesses a preponderating advantage over the shorter one, in condensing air of the greatest density, with the least proportion of power. Thus, with a vane 14 inches long, the tips of which revolve at the rate of 236·8 feet per second, the air is condensed to 9·4 ounces per square inch above the pressure of the atmosphere, with a power of 9·6 horse power; but a vane 8 inches long, the diameter of the tips being the same, and having therefore the same velocity, condenses the air to 6 ounces per square inch only, and takes 12 horse power. Thus, the density in the latter case is little more than ·6 of that in the former, while the power absorbed is nearly 1·25 to 1. Although the velocity of the tips of the vanes is the same in each case, the velocity of the heels of the vanes is very different; for whilst the tips of the vanes in each case move at the rate of 236·80 feet per second, the heels of the 14 inch vanes move at the rate of 90·80 feet per second, and the heels of the 8 inch move at the rate of 151·75 feet per second; or, the velocity of the heel of the 14 inch is in the ratio of 1 to 1·67 compared with the velocity of the heel of the 8 inch vane. The longer vane approaching nearer the centre strikes the air with less velocity, and allows it to enter on the vane with greater freedom, and with considerably less force than the shorter one. The inference is that the short vane must take more power, at the same time that it accumulates a less quantity of air.

These experiments lead me to conclude that the length of the vane demands as much consideration as the proper diameter of the inlet opening. If there were no other object in view, it would be useless making the vanes of the fan of a greater width than the inlet opening can freely supply.* On the proportion of the length and width of the vane, and the diameter of the inlet opening, rest the three most important points, namely, the *quantity* and *density* of the air, and the expenditure of *power*.

In the 14 inch vane the tip has a velocity 2·60 times greater than the heel; or, by the laws of centrifugal force, the air will have 2·60 times the density at the tip of the vane that it has at the heel. The air cannot enter on the heel with more than atmospheric density, but, in its passage along the vanes, it becomes compressed in proportion

* The proportion a suction pipe bears to a pump is an analogous case; for if we drive the bucket at a greater velocity than the suction pipe will supply it with water, the consequence will be that we shall not lift so much water, at the same time that we absorb more power.

to its centrifugal force. The greater the length of vane, the greater will be the difference between the centrifugal force at the heel and the tip of the vane; consequently, the greater the density of the air.

Reasoning, then, from these experiments, I recommend for easy reference the following proportions for the construction of the fan:—

Let the width of the vanes be one-fourth of the diameter of the fan.

Let the length of the vanes be one-fourth of the diameter of the fan.

Let the diameter of the inlet openings in the sides of the fan chest be one-half the diameter of the fan.

In adopting this mode of construction, the area of the inlet openings in the sides of the fan chest will be the same as the circumference of the heel of the vane multiplied by its width; or the same area as the space described by the heel of the vane.

The following table gives the sizes of fans varying from 3 to 6 feet diameter:—

Diameter of Fan.		Width of Vane.		Length of Vane.		Diameter of Inlet Opening.	
Feet.	Inches.	Feet.	Inches.	Feet.	Inches.	Feet.	Inches.
3	0	0	9	0	9	1	6
3	6	0	10½	0	10½	1	9
4	0	1	0	1	0	2	0
4	6	1	1½	1	1½	2	3
5	0	1	3	1	3	2	6
6	0	1	6	1	6	3	0

I recommend the proportions in the above table for densities ranging from 3 to 6 ounces per square inch; and for higher densities, from 6 to 9 or more ounces, the sizes given in the following table:—

Diameter of Fan.		Width of Vane.		Length of Vane.		Diameter of Inlet Opening.	
Feet.	Inches.	Feet.	Inches.	Feet.	Inches.	Feet.	Inches.
3	0	0	7	1	0	1	0
3	6	0	8½	1	1½	1	3
4	0	0	9½	1	3½	1	6
4	6	0	10½	1	4½	1	9
5	0	1	0	1	6	2	0
6	0	1	2	1	10	2	4

The dimensions in the above tables are not laid down as prescribed limits, but as approximations obtained from the best results in practice.

In some cases, two fans fixed on one spindle would be found preferable to one wide one, as by such an arrangement twice the area of inlet opening is obtained compared with a single wide fan; and they may be so constructed, where occasionally only half the quantity of air is required, that one of them may be disengaged by a clutch, and thus a saving of power effected. In a single fan of great width, the inlet opening must either be made too small in proportion to the width of the vane, or if it be made large enough for the width of the vane, the length of the vane becomes so short as to be quite incapable of furnishing air of the required density.

It has been stated that the air from the fan chest is impelled by the vanes along the delivery pipe to the blast chest: I beg attention to the results of experiments very recently made by me, with reference to the admission of air into the delivery pipe, which, I think, may lead to an important improvement in the fan. The experiments alluded to were made to enable me to ascertain the result of varying the area of admission to the delivery pipe, in proportion to the quantity of blast required for use; and I effected this by adapting a segmental slide to the circular chest of the fan, as shown in the accompanying drawing, by means of which I varied the depth of the opening into the delivery pipe from 12 to 4 inches.

The object of this arrangement was to diminish the delivery pipe opening at pleasure, in proportion to the quantity of air required, and thereby to lessen the power necessary to work the fan. The results will be seen by the experiments in tables 1 *a*, 2 *a*, 3 *a*, and 4 *a*. The inlet opening to the delivery pipe having been contracted from 12 inches to 4 inches deep, so that the tips of the vanes and the top of the outlet opening were nearly in a direct horizontal line, nearly the same quantity of air was impelled as with the original opening; the noise produced by the fan had however nearly ceased. It therefore appears, that the less this opening is made, provided we produce sufficient blast, the less noise will proceed from the fan; and by making the top of this opening level with the tips of the vanes the column of air has little or no reaction on the vanes.

With respect to the degree of eccentricity which the fan should have with reference to the fan chest, $\frac{1}{10}$th of the diameter of the fan

has been found in practice to answer well; that is, the space between the fan and the chest should increase from $\frac{3}{8}$ths of an inch at the top of the outlet to the delivery pipe, to $\frac{1}{10}$th of the diameter of the fan at the bottom at a point perpendicularly under the centre. The tunnel or main pipe from the fan chest may, for short distances varying from 50 to 100 feet in length, be made not less than $1\frac{1}{4}$ times the area of the delivery pipe in the fan chest; and for distances varying from 100 to 200 feet in length, $1\frac{1}{2}$ times the area of the delivery pipe. The length of a tunnel may be continued to 300 or more feet, provided it be made of sufficient dimensions to allow the air to pass freely along it. The experiments accompanying this paper were made with a tunnel 18 inches diameter and 160 feet in length, and no difference could be detected in the density of the air, when the gauge was applied at any part of the tunnel.

Having investigated the leading characteristics of the fan, it may not be out of place to give a few hints respecting its mechanical construction.

FIRST,—it is one of the greatest essentials that all parts maintain a just and proper balance.

SECOND,—The arms of the fan should be as light as is consistent with safety. Round arms are decidedly objectionable; I have known instances when their centrifugal force has torn them from the centre boss. I prefer the rectangular arm, having about the proportion of $2\frac{1}{2}$ times the width for the depth at the centre, with sufficient taper towards the tips.

THIRD,—the bearings and journals of the fan spindle should be made of a length not less than 4 times the diameter of the necks of the spindle.

FINALLY,—the driving pulleys should be made as large as circumstances will admit of, so that the strap may have sufficient surface to prevent slipping.

The fan from which my experiments were collected was made with these proportions. It has been at work nine years without any perceptible wear.

The application of the fan has hitherto been chiefly limited to smithies and foundries; and in but few instances has it been applied to the smelting of iron ore. I am aware that differences of opinion

exist as to the applicability of the fan to that purpose, the principal reason urged against it being the limited density to which the blast can be compressed by the fan, compared with the blast supplied by the cylinder. It remains however to be proved, whether such high densities are absolutely necessary for the smelting of iron ore; whether we may not produce as good iron by a diffused soft blast, as by the strong and generally applied concentrated blast. I hope it will not be thought presumptuous on my part, thus to doubt long established practices. The old maxim of "there's no way like the old way," is not always based on unerring principles.

As I have before stated, the density of blast afforded by the fan is limited to the force arising from the centrifugal motion of the air in passing along the vanes of the fan; the quantity not exceeding what is due to its velocity and magnitude. But may not this density be increased by using a succession of fans so constructed and arranged that the air may be passed successively through each; the air from the first fan being made to enter the second; the air from the second to enter the third; and the blast finally emitted of adequate density?

I cannot here enter into a further investigation of this important subject; nor are the limits and character of this paper suited to the minutiæ connected with the principles and practice of a smelting furnace; but I hope that the observations which I have made, and the principles I have endeavoured to enunciate, will be the means of instituting further enquiry; and as the expense of constructing a fan can be no barrier, I trust that a fair trial will be made, where convenience is suited to its application for smelting purposes.

Soho, October 23, 1847.

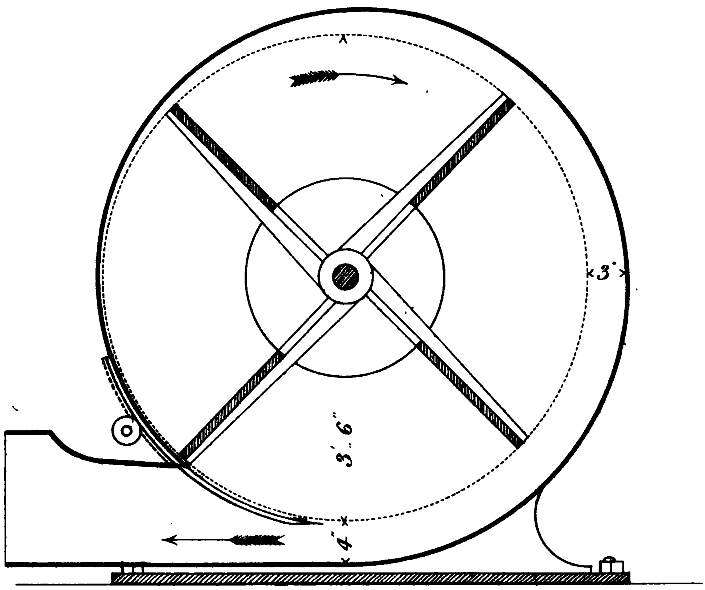
Oct. 1847.

			No. 4.				
Original Exp... diameter, ...		... and Vanes	With an Inlet Opening 20½ inches diameter, and Vanes 13¾ inches long, by 10¾ inches wide.				
No. of Experi- ments.	Num... Revol... of ... per M...	Indicated Horse Power.	Number of Revolutions of Fan per Minute.	Velocity of Tips of Vanes in Feet per Second.	Density of Air in Ounces per square Inch.	Area of Discharge Pipe in square Inches.	Indicated Horse Power.
No. 1	116	...	...	...	...	...	...
„ 2	108	6·10	1081·7	220·80	7·70	0	8·40
„ 3	100	5·96	1000·0	204·16	6·70	0	7·84
„ 4	90	4·13	900·0	183·74	5·50	0	5·20
„ 5	84	3·90	786·7	160·50	4·40	0	4·45
„ 8	106	...	1063·3	217·09	7·00	25·00	10·70
„ 10	104	...	1063·3	217·09	6·00	42·50	11·47
„ 11	94	...	966·7	196·68	6·00	35·00	10·07
„ 12	108	...	...	...	...	...	...
„ 14	95	7·30	966·7	196·68	5·00	65·00	14·04
„ 15	85	...	878·5	179·10	5·00	37·50	7·30
„ 16	108	...	...	...	...	...	...
„ 17	103	7·00	...	...	...	...	...
„ 18	96	8·90	983·3	200·70	4·00	79·60	12·70
„ 19	87	6·17	870·0	177·62	4·00	66·00	9·90
„ 20	76	...	773·3	157·80	4·00	35·00	5·70
	...	8·70	...	...	...	...	...
„ 21	98	7·29	...	...	...	...	...
„ 22	85	7·80	870·0	177·62	3·00	103·60	10·70
„ 23	77	6·76	786·7	160·50	3·00	97·10	10·42

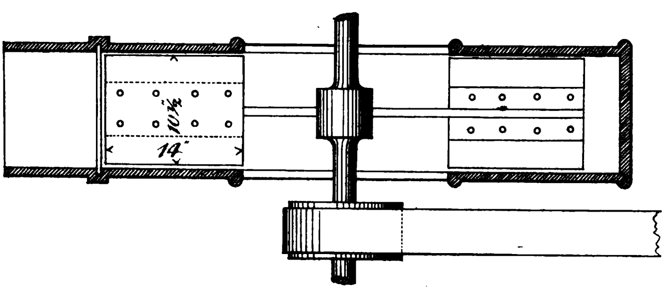
			No. 4, *a*.				
With the Outlet O... Inlet Opening 15 in...		...hes deep.	With the Outlet Opening contracted to 4 inches deep. NO EFFLUX.				
		2·75	885·0	180·70	5·50	0	3·70
			WITH EFFLUX.				
	80 88	2·40	900·0	183·74	4·00	40·00	6·90
		... deep.	With the original Outlet Opening, 12 inches deep. NO EFFLUX.				
	78 88	3·46	885·0	180·70	5·50	0	4·31
			WITH EFFLUX.				
	87 77 87	3·98	885 0	180·70	4·00	60·70	9·30

FAN BLAST.

Vertical Section of Fan.



Sectional Plan.



Scale 1/16th

INSTITUTION

OF

MECHANICAL ENGINEERS.

DESCRIPTION

OF AN

IMPROVED SUSPENSION BRIDGE,

FOR

CARRYING A RAILWAY, AND FOR OTHER PURPOSES.

BY

EDWARD A. COWPER.

PAPER READ AT THE MEETING AT BIRMINGHAM,

27TH OCTOBER,

1847.

PUBLISHED BY THE INSTITUTION.

DESCRIPTION OF AN IMPROVED SUSPENSION BRIDGE, FOR CARRYING A RAILWAY, AND FOR OTHER PURPOSES.

By Mr. EDWARD A. COWPER, of Birmingham.

The object of the present Paper is to call the attention of engineers and railway directors generally to a mode which I have invented of constructing Suspension Bridges in such a way, that they shall not *be thrown out of shape* or in *any way distorted* by the weight of a passing load, whether it consists of a railway train, or only of the ordinary traffic of a common road.

It is well known that Suspension Bridges are decidedly less costly than any stone bridges, and I may add than most iron bridges, when the span is at all above the length of an ordinary girder; and although many persons have directed their attention to them, particularly with regard to their use on railways, I am not aware that any suspension bridge has ever been made, or proposed, that was at all competent to carry the weight of a railway train in motion, or in other words, that should be safe as a railway bridge.

My attention was particularly called to Suspension Bridges, by the proposal of carrying a railway over the Hungerford Bridge, or over a bridge placed close alongside of it; and it appeared to me that the weight of a passing train would so move and distort the chains, as to cause the road very soon to get out of order, if not actually to give way, and I then devised the plan of making a chain of such depth as to include any alteration in the *curve of the strain* that might take place.

The curve which the chains of an ordinary Suspension Bridge take is well known to be a catenary, or rather a curve between a catenary and a parabola. It would be a true parabola if all the weight were in the platform, and a true catenary if all the weight were in the chain. As however the difference between the catenary and the parabola is very slight indeed, in that portion which would be used for a bridge, we may assume it to be a catenary for all practical purposes.

Now on loading an ordinary Suspension Bridge with even a small weight, it at once assumes a different curve (unless the weight be equally distributed over the bridge), and if the weight be large, it will assume a very different curve; so much indeed will the form be altered, as to injure or strain the material of which the platform or road is composed. Now it is evident that if the road has to *distribute* the weight, it must be a very strong and stiff beam, or in fact a girder of the full length of the bridge; and the strength of this girder would very nearly be equal to carrying a quarter of the weight of the load in the centre; it is therefore evident that the plan of forming a stiff platform or road for a railway suspension bridge, although by no means impossible, must be at least half abandoning the suspension principle, and be the cause of greater outlay.

The plan of keeping the road in shape by distributing any weight that might come upon it, by means of strong diagonal ties,

was the first idea that occurred; but it will be found by calculation that these diagonals would have to be very strong, and of considerable height, thereby causing the total depth of the bridge to be much greater.

But the plan on which I propose to construct Suspension Bridges, capable of carrying railway trains without being in any way injured thereby, is simply to make the chain of such depth as to include the curve of strain, when the weight is placed upon the bridge in the most unfavourable positions. With this object I construct the chains of boiler plate of considerable depth, (say 3 or 4 feet or more,) and rivet the whole well together, without any moveable joints or separate links, and at the top and bottom edges of the chains I rivet or otherwise attach bars, either flat, half-round, or angle-iron, so as to give an accumulation of metal at those parts, and, at the same time, to render the edges of the chains perfectly secure against any tendency to rip or tear.

In the accompanying Drawing, you will observe that there are two chains, each four feet deep, which support the ends of cross wrought-iron girders (in the position of sleepers), each chain being composed of four boiler plates, riveted together in pairs, each plate being $\frac{3}{8}$ of an inch thick, and at the top and bottom edges there are securely riveted strong angle-irons. The suspension bars hang between the two pairs of plates forming the chain, and are supported by a small saddle, which bears on the top edges of them. The ends of the cross wrought-iron girders are firmly secured to a light rib of boiler plate, which runs along each side of the bridge, as shown in the cross section of the bridge; the lower ends of the suspension bars are secured to the ends of the girders, with means of adjustment, so that the road may be trimmed perfectly level when the bridge is fixed. There are also light diagonal ties introduced for the purpose of more perfectly staying the road to the chains, particularly in case of the breaks being applied whilst a train is passing over the bridge.

The rails, either of the ordinary form placed in chairs, or (that form commonly called the bridge rail, are supported on ball of timber scarphed together, which run longitudinally througho the bridge, and these are supported by short balks of timber runnir from girder to girder, immediately under the first. There are series of diagonal ties placed in the platform, as shewn in plan , the drawing; these act as a means of stiffening the platform, a preventing any vibration or shaking of the parts. Stay rods a are provided, by which the bridge is prevented from moving or swinging sideways; they are attached to the piers, and are very similar to some used by Mr. Brunel, senr., in a bridge at the Isle of Bourbon.

The Drawing is of a Bridge 200 feet span, having the cross girders 8 feet from centre to centre, and the chains 4 feet deep, which depth has been arrived at by actual experiment. The weight of the road for one line of rails and one chain, is 1 ton per foot run; and the weight of a train of locomotives I have assumed at 1 ton per foot run, (and this is allowing some margin for the continued growth of locomotives) and I have taken as a proof load 2 tons per foot run; thus the weight of the load, or disturbing cause, will be just double the weight of the bridge.

I find the greatest distortion of the *curve of strain* takes place when the bridge is only half loaded, (*i. e.*) from one end to the centre; the curve then approaches the bottom of the chain, very nearly in the centre of the loaded half, and approaches the top of the chain in the centre of the unloaded half; whilst at the piers it approaches the top at the loaded end, and the bottom at the unloaded end. Again, if the same load be placed in the centre of the bridge, (covering one-half of the length) the curve of strain will approach the bottom of the chain in the centre, and will approach the top of the chain at very nearly one-fifth from each pier, whilst at the piers it will be near the centre of the chain, but rather above it.

Take one more case, and we shall have disposed of all the heavy disturbing tendencies, viz.: that of the ends loaded and the centre left unloaded, the curve of strain will then approach the top of the chain in the centre, and the bottom of the chain at about one-sixth from each pier; whilst at the piers the strain will be slightly above the centre. I may add, that when the bridge is fully loaded throughout, the curve of strain is in the centre of the chain throughout its length.

I propose to call bridges made on this plan "INVERTED ARCH BRIDGES."

(Signed,)

E. A. COWPER.

Birmingham, October, 1847.

INSTITUTION

OF

MECHANICAL ENGINEERS.

DESCRIPTION

OF THE

LUGGAGE ENGINE "ATLAS."

BY

CHARLES F. BEYER.

PAPER READ AT THE MEETING AT BIRMINGHAM,

24TH NOVEMBER,

1847.

PUBLISHED BY THE INSTITUTION.

DESCRIPTION OF THE LUGGAGE ENGINE "ATLAS."

By Mr. CHARLES F. BEYER, of Manchester.

The present communication does not pretend to lay before the Institution any peculiar novelties, but is simply confined to the description of the particular construction adopted by the makers, for this class of engine.

The Engine here to be described belongs to the class called inside-cylinder engines; has inside framings and six wheels, all of them coupled.

Its dimensions are as follows:—

18 inch cylinders, with 2 feet stroke.

Boiler 3 feet 6 inches diameter, by 13 feet 6 inches in length, containing 175 brass tubes, of $1\frac{5}{8}$ inches outside diameter; and 4 feet 6 inches wheels, made of cast iron.

The copper firebox is 3 feet 8 inches long by 3 feet $3\frac{1}{4}$ inches wide inside, and measuring 3 feet $4\frac{1}{2}$ inches from the top of the firebars to the underside of the roof.

The water spaces round the four sides are 3 inches, and that of the midfeather running across the box is 4 inches in width.

The weight of the engine in working condition is 24 tons exactly.

The order for these engines was given on the 14th November 1844, and the dimensions at that time were thought large; however the size of locomotives has been so much and so rapidly increased since, that they no doubt will appear much dwindled down at this distant period. Still the performances accomplished with them are nevertheless thought to be deserving of some attention, having to the best knowledge of the writer not been excelled either before or since.

Sheet I. represents a side elevation; Sheet II. a longitudinal section; and Sheet III. different cross sections.

Sheet IV. shows the engine in plan, and represents details of the cylinders, connecting and coupling rods, the force pump, and steam regulator, on an enlarged scale of 3 inches to the foot,—the general plans being half that size, or $1\frac{1}{2}$ inch to the foot.

The framing A consists of two single flat plates, 1 inch in thickness, to which the cast-iron slides for the axle bearings are riveted sideways.

A truss or stay B is introduced between the front and centre wheels, to relieve the forks from the strain between the piston and crank shaft.

The fastening of the two frames to the body of the engine is made at the front by means of the smokebox sides C C; and the boiler and firebox are made to slide or expand upon them, by means of mortice holes in the boiler-feet D and E, and angle pieces F, which form the connection with them.

The draw-plates G G are fastened to the two frame-plates only, without having any connection whatever with the firebox.

The cylinders are secured to each other by internal flanches; they form the bottom of the smokebox, and the principal cross stay between the two frames, to resist buffing.

The valves are inclined towards each other, situated in one chest, and, being placed below the cylinders, afford a direct exhaust to the chimney.

The weight of the valves is carried by their spindles, made to work through stuffing-boxes in both the loose end-lids. H, a cross stretcher, forged in one piece, firmly bolted to the frames A A, but unconnected with the boiler, to carry the hind ends of the steel slides I I I I and reversing shaft J, receives the front ends of the force pump, and prevents the eccentric rods M M from falling to the ground in case of breakage.

The valve spindles N, being below the front axle and not tending to the centre of the crank, a kind of pendulum lever O is introduced, for rectifying the angles, and to form the connection between the valve links and the block P, which the expansion link Q acts upon.

The steam regulator R (see Sheet IV.) is in this instance made with a second disc S, provided with two small holes T, each about $1\frac{1}{8}$ inches area, which, being acted upon first on turning the regulator handle, admits steam into the pipes and cylinders, and thus removes the pressure from the ordinary disc U before it is moved, and enables the driver, without any particular attention, to start as gradually as he pleases.

Sheets V. and VI. are diagrams of the working of the valves for a complete revolution of the wheel when going forward, taken from a full-size model.

The curves 1, 2, 3, 4, and 5, of the admission and exhaustion of the steam correspond to a traverse of the valve of $4\frac{13}{16}$, $4\frac{1}{16}$, $3\frac{5}{16}$, $2\frac{3}{4}$, and $2\frac{9}{16}$ inches.

Although one engine, the "Atlas," has been here described, it will be necessary to state, for the better understanding of the particulars connected with their working, which the writer has succeeded in collecting, that Messrs. Sharp Brothers and Co. have made six of these engines, varying only in the number and diameter of their tubes, but in other respects perfect duplicates of each other, namely:—for the Manchester and Sheffield Railway four engines, called

ATLAS,
HERCULES,
HECTOR,
JUPITER;

and two engines, Nos. 30 and 32, for the Manchester and Birmingham Railway, the last of which has been transferred since to the London and Birmingham Railway. The difference of the tube plates above referred to, and the heating surfaces and flue-areas of all the six engines, are given in full upon Sheet VII.

The engine "Atlas" was put to work on the Manchester and Sheffield Railway in May 1846, and ran up to the 31st of October last 40,222 miles in all; her consumption of coke being 37·94 lbs. per mile. For further particulars see Table II. in the appendix.

Sheet VIII. shows the wear of the tyres (Low Moor) in two opposite places of each of the left-hand wheels of the "Atlas," after running the above distance of 40,222 miles.

A table of the gradients and curves of the Manchester and Sheffield Railway is given in the appendix.

To try the capabilities of one of these engines, a train of 101 wagons, weighing 597 tons, was prepared by Mr. Salt, the Goods Manager of the Manchester and Birmingham Railway, on Saturday, the 3rd of October, 1846, for the engine No. 30 to take from Longsight to Crewe, a distance of 29 miles, and it was accomplished at an average speed of 13·7 miles per hour.

A section of that portion of the London and North Western Railway is given upon Sheet IX. The working of the train on this occasion was as follows:—

Put the steam on at Longsight	9 12	a.m.
Passed the mouth of tunnel at Stockport .	9 41	„
„ Macclesfield Junction	9 49	„
„ Handforth Station	10 1	„
„ Wilmslow Station	10 10	„
Came to a dead stop at Alderley	10 16	„
Sent the engine forward to Chelford to take in water, and		
Put on the steam again at Alderley . . .	10 54	„
Passed Chelford Station	11 8	„
„ Holmeschapel Station	11 28	„
„ Sandbach Station	11 41	„
„ Rookery Bridge	11 44½	„
Arrived at Crewe	11 57	„

The size of blast-pipe for running the above trip was 3¼ inches diameter, or 8·3 square inches.

Since the transfer of the engine No. 32 to the London and Birmingham Railway, I have received only one monthly statement respecting her performance, namely for June last. During that month she ran 3,004 miles, with a consumption of coke of 0·214 lbs. per ton per mile; the next best engine then at work on that line burning 0·38 lbs. per ton per mile.

APPENDIX.

TABLE I.

MANCHESTER, SHEFFIELD, AND LINCOLNSHIRE RAILWAY.

TABLE OF CURVES.

Distance from Ardwick to end of Curve.		Length of Curve.	Radius of Curve.	Side towards which Curve bends.
Miles.	Chains.	Chains.	Chains.	
0	11	11	13	North.
0	62	51	straight.	...
0	76½	14½	60	South.
1	0	3½	straight.	...
1	9	9	80	S.
1	44½	35½	straight.	...
1	68	23½	80	N.
2	0	12	60	N.
2	22	22	straight.	...
2	34	12	100	S.
2	69	35	straight.	...
3	9	20	80	N.
3	17	8	straight.	...
3	53	36	120	S.
3	65	12	straight.	...
3	70	5	80	S.
4	30	40	straight.	...
4	43	13	80	S.
4	48	5	straight.	...

TABLE OF CURVES—CONTINUED.

Distance from Ardwick to end of Curve.		Length of Curve.	Radius of Curve.	Side towards which Curve bends.
Miles.	Chains.	Chains.	Chains.	
4	79	31	80	S.
5	11	12	straight.	...
5	50	39	80	S.
6	1	31	80	N.
6	24	23	straight.	...
6	41½	17½	60	N.
6	50	8½	straight.	...
6	75	25	70	N.
7	18	23	straight.	...
7	33	15	17	S.
7	54	21	70	N.
8	1	27	straight.	...
8	7	6	80	N.
8	39	32	straight.	...
8	46	7	120	N.
8	60	14	40	N.
9	15	35	straight.	...
9	19	4	30	S.
9	27	8	straight.	...
9	32½	5½	30	N.
9	40	7½	straight.	...
9	63	23	40	N.
9	74	11	160	N.
10	3	9	60	N.
10	19	16	60	S.
10	37	18	straight.	...
10	72	35	40	N.
11	4	12	straight.	...
11	31	27	40	N.
11	78	47	58	S.
12	77	79	straight.	...
13	23	26	40	S.
13	53	30	40	N.
13	73	20	40	S.
14	11	18	straight.	...
14	33	22	60	S.
14	72	39	straight.	...
15	16	24	40	N.

TABLE OF CURVES—CONTINUED.

Distance from Ardwick to end of Curve. Miles.	Chains.	Length of Curve. Chains.	Radius of Curve. Chains.	Side towards which Curve bends.
15	45	29	60	N.
16	3	38	60	S.
16	24	21	40	N.
16	69	45	45	S.
17	6	17	40	N.
17	42	36	straight.	...
17	60	18	60	S.
18	7	27	160	N.
18 ...	25	18	straight.	...
18	35	10	40	N.
21	38	243	straight.	...
21 ...	66	28	40	N.
22	2	16	36	N.
22	33	31	straight.	...
22	50	17	40	S.
22	70	20	90	N.
23 ...	16	26	110	N.
23	22	6	120	N.
23 ...	45	23	70	S.
23	74	29	80	N.
24 ...	36	42	38	S.
25	4	48	40	N.
25	36	32	40	S.
25	72	36	40	N.
26	20	28	straight.	...
26	42	22	40	S.
27	20	58	straight.	...
27	67	47	50	S.
28	20	33	50	N.
28	53	33	55	S.
30 ...	12	119	straight.	...
30	61	49	80	N.
31	17	36	40	S.
31	77	60	60	S.
32 ..	41	44	straight.	...
33	14	53	60	N.
33 ...	56	42	straight.	...
34	6	30	80	S.

TABLE OF CURVES—CONTINUED.

Distance from Ardwick to end of Curve.		Length of Curve.	Radius of Curve.	Side towards which Curve bends.
Miles.	Chains.	Chains.	Chains.	
34	30	24	80	N.
34	51	21	40	S.
35	15	44	30	N.
35	59	44	35	S.
36	7	28	40	N.
36	42	35	straight.	...
36	73	31	40	N.
37	59	66	straight.	...
37	68	9	40	S.
38	25	37	straight.	...
38	44	19	35	N.
39	2	38	35	S.
39	50	48	40	N.
40	15	45	straight.	...
40	19	4	40	S.
40	24	5	straight.	...

Total length, 3224 chains; or 40 miles, 24 chains.

TABLE

MANCHESTER, SHEFFIELD, AND

LUGGAGE ENGINE

FROM MAY 1846 TO

Period of Working.	Miles run.				Engineer's and Fireman's Wages.			Coke consumed, Total.				Oil.			Tallow.			Waste and Flax.		
	Coach Trains.	Goods Trains.	Piloting.	Total.				Weight.	Cost.											
					£	s.	d.	Cwts.	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.
May to June 1846	...	..	...	2,800	11	11	4	903	31	3	10	5	5	0	1	16	10½	1	4	8½
to Dec. 1846 ...	100	17,175	105	17,380	84	10	8	5,773	203	19	0½	26	6	0½	9	17	9	6	13	3½
to June 1847...	...	12,664	26	12,690	72	2	8	4,535	151	3	4	27	13	8	8	2	6	7	19	4
to Oct. 1847 ...	...	7,352	...	7,352	39	4	4	2,414	100	4	2	12	18	4½	4	16	6	3	16	4½
Totals ...	100	37,191	131	40,222	207	9	0	13,625	486	10	4½	72	3	1	24	13	7½	19	13	8½

II.

LINCOLNSHIRE RAILWAY.

"ATLAS," No. 26,

31ST OCTOBER 1847.

Sundry Stores.	Material for Repairs.	Wages for Repairs.	Repairs not done by Co.	Cost of Tender. Material for Repairs.	Cost of Tender. Wages for Repairs.	Total Cost.	Coke consumed per mile run.
£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	Lbs.
16 11 11	0 0 0	0 16 11	0 0 0	0 0 0	0 0 0	68 10 7	36·12
4 9 2	0 19 0	8 2 10	0 9 2	5 7 1	0 2 6	350 16 8½	37·20
26 10 7	10 0 1	44 7 5½	51 5 3	6 15 7	3 10 4½	409 10 10	40·03
14 10 7	1 19 6¼	17 0 4	27 1 0	0 5 6	0 2 0	221 18 8½	36·77
62 2 3	12 18 7¼	70 7 6½	78 15 5	12 8 2	3 15 0½	1050 16 10	37·94

TABLE III.

MANCHESTER, SHEFFIELD, AND LINCOLNSHIRE RAILWAY.

LIST OF GRADIENTS.

Locality where change of gradient occurs.	Distances. Total.	Length of Gradient.	Levels. Rise.	Fall.	Gradients. Per mile.	Rate.	Height above low water at Liverpool.
	Miles Ch.	Ml. Ch.	Feet.	Feet.	Feet.		Feet.
Manchester & Birmingham Railway Station	0 14·0	0 14·0	0·00	...	0·0	level	169·56
	0 58·0	0 44·0	7·50	...	14·0	1 in 337	177·06
Chancery Lane . .	0 60·0	0 2·0	0·69	...	11·0	1 in 480	177·75
Blind Lane	0 4·0	0 4·0	0·41	...	11·0	1 in 480	178·16
Stockport Canal . .	1 75·5	1 71·5	56·92	...	30·0	1 in 176	235·08
Gorton Reservoirs . .	2 60·0	0 64·5	42·58	...	52·8	1 in 100	277·66
North Street	3 70·0	1 10·0	45·00	...	40·0	1 in 132	322·66
Guide Bridge . . .	4 20·0	0 30·0	6·00	...	16·0	1 in 330	328·66
Near River Tame . .	4 40·0	0 20·0	0·00	...	0·0	level	328·66
Dukinfield Road . .	4 63·6	0 23·6	8·76	...	30·0	1 in 176	337·42
Newton Wood Colliery	5 60·0	0 76·4	50·58	...	52·8	1 in 100	388·00
Newton Green . . .	6 56·5	0 76·5	26·77	...	28·0	1 in 188	414·77
Hattersley	8 16·5	1 40·0	56·40	...	37·6	1 in 140	471·17
Broadbottom . . .	9 26·0	1 9·5	11·63	...	10·4	1 in 511	482·80
Gamsley	10 47·0	1 21·0	55·65	...	44·0	1 in 120	538·45
Dinting	11 7·0	0 40·0	0·00	...	0·0	level	538·45
Deepclough	13 31·0	2 24·0	121·44	...	52·8	1 in 100	659·89
Woodhead, entrance to Summit Tunnel .	18 37·0	5 6·0	227·35	...	44·8	1 in 118	887·24
Summit Level . . .	21 38·0	3 1·0	79·20	...	26·4	1 in 200	966·44
Dunford Bridge . .	21 47·0	0 9·0	...	1·44	12·8	1 in 410	965·00
Ranah	24 30·0	2 63·0	...	111·50	40·0	1 in 132	853·50
Hielands	25 40·0	1 10·0	...	49·50	44·0	1 in 120	804·00
Penistone	27 15·0	1 55·0	...	67·50	40·0	1 in 132	736·50
Penistone T. P. Road .	27 22·3	0 7·3	...	0·00	0·0	level	736·50
Poorhouse Lane . .	28 0·0	0 57·7	...	38·10	52·8	1 in 100	698·40
Road at Oxspring . .	29 0·0	1 0·0	...	32·80	32·8	1 in 161	665·60
Road from Wortley to Thurgolam . . .	30 70·0	1 70·0	...	75·00	40·0	1 in 132	590·60
Oughty Bridge . . .	35 62·0	4 72·0	...	215·60	44·0	1 in 120	375·00
Sheffield Station . .	40 24·0	4 42·0	...	181·00	40·0	1 in 132	194·00
Totals	40 24·0	40 24·0	788·69	772·44			

INSTITUTION

OF

MECHANICAL ENGINEERS.

DESCRIPTION

OF THE

MULTIFARIOUS PERFORATING MACHINE.

BY

BENJAMIN FOTHERGILL.

PAPER READ AT THE MEETING AT BIRMINGHAM,

26TH JANUARY,

1848.

PUBLISHED BY THE INSTITUTION.

DESCRIPTION OF THE MULTIFARIOUS PERFORATING MACHINE.

BY MR. BENJAMIN FOTHERGILL, OF MANCHESTER.

THE accompanying drawings illustrate the details of an improved Machine for Perforating such Metal Plates as are used to form ships, steam boilers, girders, tubular bridges, and other strong works made of metal plates, with a row of holes equal in number to or fewer than the punches in the machine, which holes may be of the same or of different sizes, and at the same or different distances apart. A series of rows of such holes may be made in each plate, and any of the punches may be prevented from acting at pleasure.

In Sheet I., Fig. 1 represents a front elevation, Fig. 2 a side elevation, and Fig. 3 a horizontal section, taken through the dotted line *A A* in Figs. 1 and 2, of an improved Perforating Machine for making holes in strong plates. Fig. 4 is a detached view of the traverse apparatus; and Fig. 5 a detached view of the holding-down or stripping apparatus. In Sheet II., Fig. 6 represents a sectional elevation of the machine shown in Sheet I.; Fig. 7 an elevation of the back of the machine; Fig. 8 a plan view of the apparatus for putting the punches out of action, without stopping the flywheel; and Fig. 9 a plan view of a few of the Jacquard plates. *A A* the standards.—*B* the bed, through which there is an opening for the punchings, or metal punched out of the plate, to fall; this bed is inserted into the standards.—*C* a stretcher bar, to connect the top of the standards.—*D* a fulcrum bar of the levers *q q*, which withdraw the punches, and of the lever *w*, which traverses the plate.—*E* a fulcrum

shaft, to which the levers *j j* and *k k* are keyed.—*F* the main or eccentric shaft, working in bushes in the standards.—*G* a spur wheel keyed on the eccentric shaft.—*H* a pinion, working into the wheel *G*.—*I* the flywheel shaft, on which are the fast and loose pulleys *K* and *L*, the pinion *H*, and the flywheel *J*.—*M M* connecting rods, fitted to the eccentric necks of the shaft *F*.—*N N* caps of the connecting rods *M M*.—*O O* guide plates for the punch rams *P P*.—*Q* the cam shaft.—*R* a spur wheel, loose on the cam shaft, and having on one side two projections, between which there is an opening.—*R** a locking disc or plate, keyed on the shaft *Q*, having upon it a spring catch 38, which takes into the opening between the projections on the wheel *R*.—*R* and *R** are seen detached on Sheet II., and the dotted lines on *R** represent a weight to counterbalance the levers *K*.—*S* a toothed wheel, keyed on the main shaft *F*.—*T* the punch ram depresser, secured to the connecting rods *M M* by knuckle joints at the lower end of the connecting rods.—*U* a slide-bar on which the frame traverses which carries the plate to be punched.—*V V* two short slide-bars, to carry one side of the traverse frame.—*W* a block of iron fastened with short wedges to the bed *B*, to carry the die plate *X*, into which the dies *d* are inserted, and prevented from rising by a collar at the lower end of each, as seen in Fig. 5.—*Y* a square shaft, carrying the holding-down levers, or stripping fingers *o o*.—*Z Z* levers on each end of the shaft *Y*.—*a a* the punches let into the punch-holders *b b*, bolted to the rams *P*, as seen in the detached views on Sheet II.—*c c* pieces bolted to the bed *B*, to carry the adjusting slide-bars *V V*.—*d* dies inserted into the holder *X*.—*e e* (see Fig. 6) are the selecting slide-bars, which, when allowed to pass through the card plate, enter the card roller *f*, without being pushed backward by the plate; the card roller has in this case six sides, and the belt of Jacquard plates, after passing over it in the usual manner, travels over a round roller suspended in a swing frame at such an angle as shall keep the belt moderately tight, whilst the roller *f* advances towards and recedes from the selecters *e*.—*g g* brackets projecting from the depresser *T*, and carried up and down with *h h* its sliding blocks, in which the journals of the card-roller turn.

To an upright cast on each of these blocks is fitted a rod of round iron *, with a flat foot long enough to extend over two of the six pins in the end of the card roller, against which the flat foot of the rods is made to press by spiral springs coiled around them in the usual manner employed in the Jacquard loom, which being generally known need not be further described.

i i (see Fig. 6) are two sets of guide blocks for the selecters *e*, one on each side of the depresser, adjustable laterally by set screws on flat bars *O* extending across the machine. The use of these blocks is to carry the selecting bars *e*, which are round at the end which enters the cards, and flat at the other end, to keep them in their proper positions; the centre portion of each selecting bar is a solid piece of iron projecting as much below the round stem as will, when the selecting bar is driven backwards by a card plate, permit the depresser *T* to complete its downward stroke without the selecting bar touching the ram *P* under it.

j j are levers keyed on the shaft *E*, and connected at their lower ends by links to the slide-blocks *h h*.—*k k* also are levers keyed on the shaft *E*, and having each a friction roller at its lower extremity. On the shaft *Q* are two cams, one of which works the lever *k* on one side of the shaft, and the other cam works the other lever *k* on the opposite side. One of the cams, through the medium of the levers *j j* and the links before referred to, causes the roller *f* to approach the selecting bars *e*, and the other cam causes the roller to recede from them, until, by a catch employed in the ordinary way in the Jacquard looms, the roller *f* is made to turn through one sixth of a revolution, and is then retained in that position by the pressure of the spiral spring and flat foot above referred to.

l l are brackets attached to the depresser *T* at the back of the machine, seen best in Fig. 6.—*m* a bar resting on the brackets *l l*, and connected by rods with the sliding blocks *h h*, which on receding cause the bar *m* to bring all the selecting bars *e* into the position for depressing the rams, as seen in Fig. 6.—*n n* are levers having their

fulcra on studs screwed into the standards; one end of these levers is connected by a rod *p* with the levers *Z Z*; the other end is furnished with a roller which is acted upon by a cam *u* on the shaft *Q*, see Fig. 2.—*o o* are the holding-down levers, adjustable laterally on the shaft *Y*, so as to admit of one of them being placed on each side of every punch.—*p p* are rods connecting the levers *n* and *Z*. By adjusting the length of these rods the levers *o o* are made to press upon plates of different thicknesses, so as to hold the plates down while the punches are being withdrawn.—*q q* levers turning on the fulcrum bar *D*, for withdrawing the punches by means of the cams *r r* that actuate the levers *q q*.—*s* a broad but rather thin bar, extending through the series of punch rams *P*, shown by dotted lines in Figs. 1 and 7.

The punch rams *P* are made with slots, through which the bar *s* passes, and these slots must be about two inches longer than the width of the bar *s*, in order to allow the punch rams to be forced down when the bar is at the bottom of its stroke.—*t t* are links connecting the bar *s* with the levers *q q*.—*u u* are cams which depress the holding-down levers *o o*, through the medium of the levers *n n*, rods *p p*, and levers *Z Z*, and hold down the plate while the punches are being withdrawn.—*v* a cam for the traversing rack 5.—*w* a lever turning on the fulcrum bar *D*, and worked by the cam *v*.—*x* the cam for lifting the rack 5.—*y* a lever turning on a stud in the standard, and worked by the cam *x*, for lifting the traversing rack 5.—*z* a rod connecting the lever *y* with the lever 8, seen best in Fig. 4.

1 is a lever on the traverse shaft 2.—3 another lever on the shaft 2.—4 a link connecting the lever 3 with the rack 5.—6 a rod connecting the lever *w* with the lever 1, for traversing the rack 5.—7 a shaft for carrying the levers 8, 9, and 10.—11 a link connecting the levers 10 and 12.—13 a shaft carrying the levers 12 and 14.—15 and 16 are links connecting the rack 5 with the levers 9 and 14.—17 the upper or retaining rack.—18 a stud carrying the elbow lever 19, which is provided with a handle.—20 another stud carrying the elbow lever 21, which is connected by a link 22 with the lever 19:

the rack 17 is carried on studs, in the horizontal arm of the levers 19 and 21.—23 division studs in the bar 24 of the traversing frame.

The plate to be punched is put into a traversing frame, formed of two side bars 24 and 25, and two stretcher bars secured by cotters to the side bars, which are rabbeted to support the plate, and, when required, furnished with clamps to hold the plate down.—24 represents one of the sides of the traversing frame, in which there is a groove to fit on the slide-bar *U*; into the outer side of the bar 24 is screwed a series of studs 23, represented in the drawing as being 12 inches from centre to centre apart from each other; the side 25 of the frame slides on the bars *V V*. When the plates to be punched are very long, rollers may be used to carry the projecting ends of the traversing frame.

In Fig. 3 is shown part of a frame, with a plate partly perforated. The racks 5 and 17 (see Fig. 4) are drawn with three teeth in the length of a foot, which will divide plates to a 4 inch pitch; but it will be obvious that for a different pitch the racks must be changed, and it may in some cases, such as when the pitch required is not an aliquot part of a foot, be necessary to alter the distance between the studs 23.

Fig. 4 represents the traverse apparatus in the position it will be in when the retaining rack is down, and the punches in the act of passing through the plate, the traversing rack having completed its return stroke. When the punches are being raised, the traversing rack will rise also; and by the side piece 26, which is attached to it, acting against the roller 27 on a stud in the rack 17, will raise it also, and set the frame at liberty to be advanced by the cam *x*, through the mechanical means already described. In Fig. 6 this traverse apparatus is shown in the position it assumes when the plate is advancing. The spiral spring 28 acts on the lever 21, and forces the rack 17 down on to the pins 23.

For every hole required to be punched in line with the width of the plate under operation, a corresponding hole must be made in a plate of the Jacquard; and an additional hole, marked 30, (see Fig. 9,) is also made, into which the stopping bar 31 enters at every stroke until the punching be completed; at which time the Jacquard plate 32, which is left blank, will push all the selecting bars *e* beyond the rams *P*, and at the same time, by pushing the bar 31, disengage the cam shaft *Q*, by the mechanism to be hereafter explained, at the point where the punches and the levers *o* are held up, and thus will allow the perforated plate to be taken out of the machine, and another plate to be put into it. A lateral motion may be given to the plate which is being perforated by this machine, in the same manner as is hereinafter described in the machine for perforating thin plates of metal. The stopping bar 31 is provided with a projection on its lower surface, which depresses the click lever 39, when the bar is pushed back; the lever 33 is keyed on a shaft 34, moving on bearings at the back of the depresser; on the other end of the shaft 34 is keyed the lever 35, to the upper end of which is attached the link 36, connecting it with the elbow lever 37. The end of the other arm of this lever is inclined, for the purpose of unlocking the plate *R**, and is provided with a stud, on which is a latch 38, the tail of which comes in contact with the incline on the elbow lever 37, when it is in the position shown by dotted lines in Fig. 8; and as the wheel *R* revolves, the latch becomes disengaged from the opening between the two projections cast on the said wheel, at which time the cam shaft *Q* ceases to revolve. When the stopping bar 31 has been pushed back, it depresses the lever 39, and liberates the lever 33 from behind the projection on the lever 39, when the spring 40 will pull the elbow lever 37 into the position shown by the dotted lines.

To the blocks *h* a small shaft is attached, on which are two levers, suspending by links a plate of metal similar to a blank card plate, except that the holes for the guide pins are cut at the bottom edge. At each end of the same shaft is a lever handle, held up or down by a side spring in the ordinary way. The use of this

apparatus is as follows :—should it be required to stop the machine before the plate is finished, by raising the lever here referred to, the blank plate will come in front of the roller, and will act the part of a blank Jacquard plate, and stop the machine.

Having now described the principal parts of this machine, I shall proceed to explain the manner of its working. The plate to be punched, having been placed in the traversing frame, on the slides *U* and *V*, is then pushed forward. In its progress, the first pin of the series 23 passes under the inclined end of the rack 17, until the first notch in the rack falls upon the pin. The driving strap being now on the fast pulley *K*, the machine is set to work by pulling down the handle 42, keyed on the shaft 34, until the lever 33 is latched by the click lever 39 ; the elbow lever 37 is then, by the spiral spring 40, brought into the position shown in Fig. 8 ; the latch 38, being now liberated, will, by the action of the spring 41, (see Fig. 6,) drop into the notch in the wheel *R*, the first time it comes round ; the cam shaft *Q* will now revolve at the same speed as the shaft *F*, and the Jacquard roller *f* will be drawn back, and made to perform one-sixth of a revolution on its centres, after which it will be advanced, and the first card of the series will remove those selecting bars for which there are no holes in the Jacquard plate ; the other selecting bars will remain over their respective rams *P*, which will then force down the punches through the plate, by the descent of the depresser *T*. A little before the punches have gone through the plate under operation, the levers *o* are made to press upon it, and are held there while the punches are being withdrawn by the bar *s*, which rises simultaneously with the depresser *T* during one-half of its ascent. Whilst the depresser is continuing its ascent and descent through the other half of the stroke, the roller *f* recedes, and draws with it the bar *m*, which brings all the selectors again over the punch rams *P*. The roller *f*, while receding, having performed another sixth of a revolution, will, on advancing, bring another of the Jacquard plates against the selectors, and the operation will be repeated until all the holes are punched in the plate under operation.

AN IMPROVED MACHINE FOR PERFORATING THIN SHEETS OF METAL, AND PUNCHING METAL SURFACES, SO AS THEREBY TO FORM VARIOUS DEVICES OR PATTERNS.

Many parts and movements in this machine are almost identically the same as in the machine for punching and perforating strong or thick plates, previously described, and it will be consequently quite unnecessary to notice them here. Of this class are the standards, the eccentric shaft and connecting rods, the driving shaft, fast and loose pulleys, cams and levers, cam shaft, and toothed wheels.

In Sheet III., Fig. 10 represents a vertical section of the machine, taken at right angles to the row of punches. *A A* is the bed, which differs from that already described, principally in being made of two flat plates of cast iron, bolted against pieces of iron *B*, which regulate the distance between the plates, instead of being cast in one piece; or the pieces *B* may be cast on one, or partly on both plates.—*C* one of many pieces of steel, accurately fitted to each other, and to the angular recess in one side of the bed, and made fast to the other side (over which they project, for the convenience in handling,) by the screw *D*. Each of the pieces *C* is perforated, in reference to the other pieces, in such manner that, when the pieces are put in their places, the row of holes in the series shall be such as may be required; but, for the sake of perspicuity, we shall consider the holes in this instance to be in a straight line, and all of the same size; and to avoid repetition shall premise, what must be evident to any one acquainted with the subject, that the number and distance of the holes in each row will be the same as the number and distance of the punches, wire springs, and guide wires.

E an iron casting, secured at its ends to a flanch on each end of the standards, in such manner as will admit of its being readily withdrawn, to enable the punches, the dies, and the other parts of the machine hid by it, to be examined.—*F* the punch guide fastened by screws to *E*, which also serves as the stripper off, by holding down the plate whilst the punches *H* are being withdrawn by the flanch at the bottom of the bar *G* lifting against the underside of the heads of the punches; the flanch at the top of *G* is to strengthen it.—*J* the punch rams, kept in the vertical position by pieces of thin flat wire, made fast in the dovetailed grooves *K K* by pouring soft metal when in a molten state into them, in the manner usually practised in similar cases by stocking and lace machine makers. The piece *G* is held against the piece *E* by vertical slide pieces at its end.—*I* one of the series of wire springs in the lower flanch of the piece *G*, to keep the series of rams *J* vertical.—*L* is the depressing bar, extending across the machine, and moving in vertical slides in the standards.—*M* is a tempered steel bar, let into a groove in the bar *L*, and held there by bolts.—*N* is a plate of brass, extending across the machine, and screwed in the bar *L*.—*O* is another plate of brass extending across the machine, which is also screwed to the bar *L*.—*P* is a selecting block, of which there is a series, corresponding in number with the punches. In each end of this a round wire is fixed, one marked *Q*, and the other *R*. The wires *Q* and *R* work in holes in the plates *N* and *O*, of which there is a number corresponding with that of the punches.

The bent wire spring *S* is inserted by an elbow end into a hole in *O*, and the other end through a hole in the block *P*, into both of which holes it enters easily. Its office is twofold, namely to press the block *P* in the direction of the arrow, and to keep it in its proper position in reference to the bars *M* and rams *J*.—*T* is a four-sided prism, turning on bearings attached to *L*, over which perforated cards or card plates are made to pass in chain, after the well-known manner of the Jacquard for weaving figured fabrics. The prism *T* is represented in the drawing as having a groove on each side, extending throughout its whole length, instead of a number of holes

corresponding to the number of wire needles or selectors in the ordinary way. The groove prism will suit cards of various pitches or degrees of fineness.

In this machine the plate to be perforated, marked *U*, is clamped or otherwise secured to a traversing frame, such as is generally used for that purpose, to which the following addition is made, for varying the pitch in reference to the forward motion while the plate is under operation; namely, when a screw is employed to advance the plate, either the collar or the nut in which the screw works is made to slide a little in the direction of the length of the screw, on the piece to which the same is usually attached: this sliding of the nut or collar may be regulated by a cam or eccentric; and the same principle of retarding or accelerating the plate is applied when a rack and pinion are employed.

In addition to the longitudinal traverse, there is given to the plate a lateral motion, which may be regulated by a cam or cams, or by an eccentric or eccentrics, according to the nature of the devices or patterns to be punched or perforated by the machine. To adapt the mechanism for producing such compound movements, the longitudinal sliding frame is made to traverse upon a cross slide, the manner of constructing which, and of communicating motion to the cams, will vary according to the pattern required, and need not be further noticed here, as it will suggest itself to any competent mechanic.

Fig. 12, on the same sheet, shows a different arrangement of mechanism, for putting out of action at each stroke of the machine such punches as are not required to be used. The principal difference consists in the wires *Q*, when pressed by the cards, pushing the punch rams *J*, which move on the punch head as a fulcrum, beyond the reach of the steel depresser *M*. Another slight difference is made in putting the wires *Q*, and the prism *T*, to move up and down with the piece *G*, instead of with *L*, as shown with reference to Figs. 10 and 11.

It will be obvious, on inspection of the drawings, that two of these machines may be put to face each other on the same standards, and that a greater number, if required, may be put in series; and from what has previously been said respecting the part *E* resting on a flanch on the standards, it will be seen that the parts *E* may be slid out, for inspection and repairs of the punches, &c. As two or more series may be employed at the same time on the same job, and each series of a different size or form to the other or others of them, it follows that by due care in making the designs, and in the adjustments of the mechanism, an immense number of patterns may be produced with the same set of punches.

It will also be apparent that large punches, having *set* patterns, may be used in conjunction with small punches which are under the influence of the Jacquard. Large punches with *set* patterns may also be brought into operation by means of the Jacquard.

In Sheet III. is represented a machine (similar in principle to that just described) adapted to perforate paper and thin sheet metal, such as sieves and window blinds are made of, in which plain perforations arranged in squares may be made by a single row of punches; and perforations arranged quincuncially may also be made with a single row of punches, by giving to the plate a lateral alternating motion; but a double row of punches, arranged intermediately with each other, is preferable. Each of these arrangements admits of a great variety of fancy patterns, by the application of the Jacquard principle.

A large class of patterns may be produced by punches of various forms and sizes which shall be so grouped together as to give to the work a columnar effect. And the range of this class may be extended by giving the plate a zigzag or waved motion; and still further by combining it with the Jacquard.

AN IMPROVED ARRANGEMENT AND COMBINATION OF THE PARTS OF A PUNCHING OR PERFORATING AND SHEARING MACHINE.

A combined Punching and Shearing Machine, suitable for punching and shearing simultaneously plates and bars of metal, is represented in the drawings annexed.

Fig. 13 is a front elevation of the end of the machine to which the shears are applied.—Fig. 14 is an elevation of the punching end of the machine; and Fig. 15 is a side elevation of the machine, showing the shears at one side and the punch at the other.—Fig. 16 is a front elevation, and Fig. 17 a side elevation, of another of the improved modes of driving the combined punching and shearing machine.

In Figs. 13, 14, and 15, *a* represents the frame or standards, to which all the working parts of the machine are attached.—*b* is the driving shaft.—*c* a pinion fixed upon it, and driving the wheel *d*, which is keyed on the eccentric shaft *e*.—*k* is the flywheel, on which are cast clutches, taking into clutches cast on the pinion *c*. The object of these clutches is to connect the pinion with the flywheel in a more perfect manner than can be done by keying them to the shaft.—*f* represents the eccentric for working the shears, and *g* the eccentric for working the punch, both turned out of the solid of the shaft *e*.—*h* is the sliding plate, to which the upper blade of the shears is secured; and *i* is the connecting rod for working the slide *h* up and down.—*l* is the connecting rod reaching from the eccentric *g* to the projection *m* cast on the plate *n*, to which is attached the punch holder.

The punch slide *n* is lifted up after every stroke by the following contrivance:—upon the shaft *e* is an eccentric *o*, which acts against a roller on a pin in one arm of the lever *p*, which turns on a stud

fixed in the standard *a*. The link *s* decends from another arm in the lever *p*, and is connected with the lever *t*, the fulcrum of which is at *t**. The other end passes through a slot in the frame *a*, and takes into an opening provided in the punch slide *n*.

The eccentric *g* produces a stroke of rather more than twice the thickness of the strongest plate to be punched by the machine, but the eccentric *o* causes the punch slide *n* to rise only a little above the thickness of the same, thus giving the person who attends the machine a better opportunity of setting the plate, than if the punch were taken up the whole length of the stroke of the connecting rod *l*. If he should fail to set the plate correctly in due time, he can prevent the punch from descending, by pulling the handle *q* in the direction of the arrow : this motion will remove the connecting rod *l* from its vertical position over the projection *m*, by means of the link *r*, which connects the rod *l* with the short lever projecting from the handle *q*. Upon the same shaft as the handle *q* is fixed a lever and weight *u*, the object of which is to retain the connecting rod *l* in the position it has been placed by the workman. The die and the stripper or holder-down are made in the usual manner.

In Figs. 16 and 17, *A* represents part of a frame or standard of a machine similar in its general construction to that described with reference to Figs. 13, 14, and 15; the only difference being in the method of driving the eccentric shaft *B*, upon which in this instance is fitted a pulley *C*, connected firmly with the flywheel *D* and spur pinion *E*, to work loose on the eccentric shaft. The pinion *E* gears into a wheel *F* keyed on the top shaft *G*, on which is also keyed a pinion *H*, gearing into a wheel *I* keyed on the eccentric shaft *B*. The pinions are to their wheels respectively in the proportion of one to three; consequently the eccentric shaft *B* will make one revolution for nine revolutions of the driving pulley *C*. The proportions between the diameters of the wheels and pinions may be varied to suit the work to be executed by the machine. Machines of this description may be made to punch on both sides or to shear on both sides, instead of punching on one and shearing on the other.

A machine such as is represented in Sheets I. and II. was made for Mr. Evans, the contractor for the iron tubular bridge which is to carry the Chester and Holyhead Railway over the River Conway at the town of that name. This machine is employed to perforate the plates for the bridge, and is at present adapted to punch such pitches only as that work requires, viz., 3 inches and 4 inches from centre to centre of the rivet holes, with latitude for departing considerably from those (general) pitches in the lateral rows of holes. It is constructed to perforate at each stroke a row of holes 3 feet 5 inches broad; but, by employing a series of card plates similar to the cards used in the Jacquard loom, any number of punches may be put out of action at pleasure; and, by means of a blank card at the end of the series, the machine is put out of action at a point where no obstacle is presented to the taking out of the perforated plate, and putting a blank plate in its stead. The operation of changing plates, weighing 6 or 7 cwt. each, is performed by half a dozen men in less than one minute; and whilst one plate is being punched, these men get another ready to put into the machine. As this machine makes 11 to 12 strokes per minute, it follows that with a 4-inch pitch a 12 feet plate may be punched in less than four minutes, and consequently that (allowing one minute for changing) the machine may perforate twelve such plates per hour. Many of the plates in the bridge are 12 feet long, 2 feet 8 inches broad, and $\frac{3}{4}$ inch thick, and are punched for rivets 1 inch in diameter.

As there are but few engineering concerns where such a perforating machine as that at Conway could be employed more than an hour or two per day, it appears to me to be very desirable that ironmasters should have them, and that they should also have machines for straightening and bending plates. By these means they would be enabled to supply their customers with plates in a fit state for being riveted together.

Were this system brought into practice, engineers would direct their attention to adapt their work to the capabilities of the perforating machine; and thus great perfection, despatch, and economy of construction would be the result.

PROCEEDINGS.

APRIL 26, 1848.

The usual GENERAL MEETING of the Members was held in the Theatre of the Philosophical Institution, Cannon Street, Birmingham, on Wednesday, the 26th of April, 1848; GEORGE STEPHENSON, Esq., President, took the chair at five P.M.

The PRESIDENT, in a few remarks, congratulated the members on the prosperous state of the Institution, and expressed the pleasure he felt in meeting so many of the eminent mechanical engineers of England. He would come amongst them as often as he possibly could, for it gave him sincere pleasure to do so. He then called upon the Secretary, Mr. Kintrea, to read the minutes of the previous meeting; which were confirmed.

The PRESIDENT said the first subject that would occupy the attention of the meeting was "On Boring and Fitting up Cylinders for Locomotive Engines;" on which a paper had been read at the last meeting by Mr. Beyer. Mr. Beyer was now unavoidably absent, and Mr. Fothergill had been requested to explain the construction and mode of operation of the machine referred to.

Mr. FOTHERGILL did not consider it necessary to read the paper again; but he entered into a verbal description, referring from time to time to the drawings which accompanied the paper.

Mr. FENTON, of Leeds, considered that the operation was somewhat complex as regarded the chipping of the cylinder, and employing the conical plates.

A

Mr. McConnell said:—I can bear testimony to one part of Mr. Fothergill's statement. About three years ago, one of the engines made by Messrs. Sharp and Co. had a split cylinder, and I wrote down for another to replace it. In three days I had a cylinder sent up, which actually fitted in every particular, so that not a file had to be put upon it; showing the perfect manner in which they were got up.

The President said that the fact stated by Mr. McConnell was very satisfactory; there could be no doubt that the idea was of importance; and the thanks of the Institution were due to Mr. Beyer for his valuable communication.

The Secretary then read the following Paper, by Mr. F. Bashforth, M.A., Fellow of St. John's, Cambridge:—

ON THE FORMATION OF THE TEETH OF THE DRIVERS OF PIN WHEELS.

The proper form of the teeth of wheels is a subject that has long engaged much of the attention of mechanicians; and for many purposes all desirable accuracy has been attained. Still cases occur where the ordinary spur wheels cannot be employed, and various substitutes have been tried on different occasions with more or less success. Professor Willis has shown that the proper form for the teeth of spur wheels is a compound of portions of epicycloids and hypocycloids. He confined his attention to the *proper forms of the teeth*, and to the means of *describing them*. I am not aware that self-acting machinery has been applied to give those forms to metal wheels when mounted on their axes; and until this is accomplished, little can be expected beyond an improvement in the ordinary application of spur wheels.

From the facility with which almost perfect forms may be given, by simple self-acting machinery, to the teeth of the drivers of pin wheels, I think this old system worthy of attention. I am not aware that the method employed in the formation of the accompanying cast iron model has ever been previously used, or recommended in any publication; but it has at least the merit of being simple and capable of any degree of accuracy.

It is well known that if the pins be supposed to be mathematical lines, the proper forms of the teeth of the driver will be portions of the epicycloids described by a point in the circumference of the pitch circle of the pin wheel, when caused to roll on the pitch circle of the driver. But suppose the tracer to become a cylinder, with the above mentioned tracing *point* in its axis; the interior edge of the curve so described will be the proper form for the tooth adapted to drive pins of the same diameter as the tracing cylinder.

If the tracer be replaced by a cylindrical cutter, this, as it revolves on its own axis, which is caused to move in the proper epicycloid, will form with accuracy the interval between two teeth of the driver. By turning the wheel to be cut through the proper angle, the interval between the next two teeth will be formed; and so on till the whole is completed.

I propose that the pins should be formed in two parts,—a solid cylinder surrounded by a tube of iron. These might be polished and casehardened. The interior cylinder must be of sufficient strength to withstand the stress of the machinery, and when the tooth of the driver came in contact with the outer case of the pin, this would revolve through a small angle, and thus all abrasion of the teeth of the driver would be avoided.

Although I am fully aware of the difficulty of giving the necessary accuracy to the teeth of metal wheels, when applied to *increase* the angular velocity of an axle, still I think this method might be applied with a reasonable prospect of success to the screws of steamers, and if successful there, to a great variety of other purposes. Wooden teeth of any size could in like manner have accurate forms given to them, but it would perhaps be found difficult to keep them in their places.

Mr. McConnell observed that he did not conceive, from this description by Mr. Bashforth, that his plan of cutting the teeth was anything different from that which was usually employed. Mr. Bashforth might imagine it was new, but he (Mr. McConnell) believed that all pattern makers, or all he had ever seen making wheels, were accustomed to pursue the same method as Mr. Bashforth had described. The form of teeth was decidedly what was used in the old cog and drum corn-mill teeth a century ago. However the gentleman being an amateur deserved credit, for he no doubt had conceived the idea.

Mr. E. A. Cowper said he did not agree with Mr. McConnell: this plan had the old trundle and spur wheel in it, but the teeth, if made according to the description, would be an epicycloid struck by the circle of the pin wheel, and the particular application of the machine was a circular cutter of the same diameter as the pins, which should cut the teeth in the wheel; and if the teeth in the wheel were struck by a cutter exactly the diameter of the pin which was to work with them, they must be the true shape. It was the only proposition for a machine to cut epicycloid teeth by the operation of the machine itself.

Mr. McConnell stated that in his earlier days they used to strike out all the teeth of the wheel by the teeth of the pinion. The invariable rule of all the mill-wrights in that part of the country was to take the cog wheel and pinion, and strike out the teeth of the cog wheel from the pitch line of the other;—the principal plan of forming the epicycloid.

Mr. Fothergill said there was another method, namely, instead of striking the wheel out with the compasses, in the way to which reference had been made, which was the old plan, to take two blocks, representing the pitch lines of the two wheels; let these two come in contact one with the other, and have a sheet of tin upon the wheel or the pinion block, and put a projecting point over it from the other block alternately, and let them describe the form of teeth required, so that the one shall describe the form of teeth in the pinion, and the other the form of teeth required in the wheel; that being the most true and legitimate principle, so far as he knew, of striking wheels in use at the present time. He did not see anything new in the present proposition, but the idea might be original with Mr. Bashforth, and they ought to give that gentleman credit for it: at the same time he decidedly considered that they had at the present time much improved upon the method now brought before them.

Mr. Buckle thought that a great deal of merit was due to the author of the paper; and he believed the idea suggested might be found to be useful. In these remarks the President entirely agreed.

The next Paper was by Mr. Thomas Craddock, of Birmingham:—

ON A BOILER AND CONDENSER SUITABLE FOR EXTENDING THE CORNISH ECONOMY AND FOR PREVENTING BOILER EXPLOSIONS.

In submitting to the meeting the subject of this paper, it appears desirable to call attention to the well established practical data, from which, by the Cornish system of generating and using steam, such economical results have been obtained. To this end a very brief review of the various laws or principles immediately bearing upon the subject seems to be essential for placing the matter in its proper light before the meeting. For this purpose perhaps the classified mode is the preferable one.

Firstly, we have to do with the laws by which heat is transmitted from hotter to colder bodies, and *vice versâ*. These demand in the steam boilers and condensers an extensive surface, and, as far as other circumstances will allow, that such surface be composed of thin metal. It is further necessary, if we would produce the greatest economy in the generation of steam, that the heat produced in the furnace be to as great an extent as possible absorbed by the water; this is best effected by a subdivision of the gases, by a slow draught, and by completely surrounding the combustible matter in the furnace by the water in the boiler.

Secondly, the hydrostatic laws require, in order to render high pressure steam equally safe from explosion as low pressure, that we diminish the sectional area of the interior surface of the boiler upon which the pressure of the steam acts, in the same ratio as we increase its pressure. If we do this, then the rending force tending to burst the boiler remains the same at whatever pressure the steam be generated.

Thirdly, the laws relating to latent and sensible heat, when considered in combination with large volumes of water, and subjected to the casualties attending the steam engine, suggest the diminishing the quantity of water necessary in steam boilers, as far as practical circumstances will permit, as one of the surest means of preventing destructive boiler explosions. The importance which attaches to the suggestion these laws present becomes apparent when we consider the effects in case of explosion, which such an amount of sensible heat produces as that contained in the large volume of water necessitated in boilers of 60 horse power, for instance, and of the usual construction;

as the sensible heat contained in so large a volume of water would, supposing the pressure of the steam to diminish from 40 lbs. to 20 lbs. per square inch, generate a volume of steam at 20 lbs. pressure, equal to 30,000 cubic feet. Here we have a cause equivalent to the diffusive and destructive effects exhibited in common and large boiler explosions. The boiler to which this paper refers reduces the danger from this cause nine tenths, though the steam be generated in it at a temperature and pressure of 100 lbs. per square inch. In this case, we find the sensible heat contained in the water required by such boilers would give but 3000 cubic feet of steam at 20 lbs. pressure. The boiler under consideration is equally successful in diminishing the risk from explosion, arising from the rending strain due to the pressure of the steam; as on a comparison with the common boiler, in which we suppose the steam at only 36 lbs. pressure, we find the rending force to be 5400 lbs., whilst in the tubular, even with 100 lbs. pressure, the rending force amounts to only 900 lbs., or but one sixth of that given in the instance of the common boiler. The most obvious and certain conclusion to which such well established principles lead cannot fail to show how ill-grounded and unscientific must be the objections raised against high pressure steam when generated in such boilers.

Fourthly, the laws relating to the expansive action of steam plainly indicate the importance of the two leading features of the matter before the meeting, namely, that of removing the atmospheric pressure from the exhaust side of the piston, on the one hand, and on the other, enabling us to make use of high pressure steam with safety; as by the removal of the atmosphere in non-condensing engines an economy is produced by this cause alone equal to 38 per cent., and by increasing the pressure of the steam at the commencement we can obtain a further increased economy upon the Cornish system equal to 40 per cent.

My boiler and condenser form part, only, of arrangements which have been practically proved to give the following advantages:—an increased extent of grate surface: a slow rate of combustion: great extent of heating surface for the fire to act upon: increased facility for generating the quantity of steam required: water free from deposit for the use of the boiler: removal of the atmosphere from the exhaust side of the piston: insurance of safety from explosion: great facility for generating the steam under higher pressure, by which the

expansive principle is much extended: diminished tendency to priming: an effectual means of preventing the loss arising from steam blowing away at the safety valve: self-adjusting means for keeping the steam at a uniform pressure, whatever the pressure desired may be: a continuous supply of pure water for the use of the boiler, it not requiring a *fresh* supply of more than one gallon per horse power per day to make good that lost by leakage: the engines and boilers compacted into a much less space, and not half the weight, for equal power, of those in general use.

A small working engine was placed before the meeting.

The PRESIDENT enquired whether there would not be a liability in the top and bottom chambers to give way.

Mr. CRADDOCK replied that he had had these boilers in use for five years and he had worked them as high as 130 lbs.; but in general from 60 to 80 up to 100 lbs., and he had never detected any leakage whatever.

The PRESIDENT:—You expect a saving of fuel in this, I suppose?

Mr. CRADDOCK:—I do; but I am not at present prepared to submit the exact amount.

The PRESIDENT:—What vacuum do you get?

Mr. CRADDOCK:—I have got from 24 to 26 inches of mercury, and I do not despair of getting 28. I hope to be able very shortly to show an engine of 40 horse power, which shall not take half a horse power to drive the condenser. It will not take so much power to work the air pump on this principle, as by the injection system. I do not propose this as a substitute for water, by any means; but I propose to carry that principle into every place where air can be obtained, so far as other practical circumstances will admit.

The PRESIDENT:—I think it requires a very ingenious mind to follow you.

Mr. McCONNELL enquired if any trial had been made of the engine in actual work.

Mr. CRADDOCK replied that it had been tested at the London Works at Smethwick, and referred to Mr. Cowper of that establishment for the particulars of the trial.

Mr. COWPER:—Mr. Craddock brought the engine to our Works, and

as near as I can remember, the results were,—that the horse power was 22 and a fraction, indicated horse power; and the condenser took one and a half horse power to drive it. I think it may have been less, but not more, while the engine was doing the work of 22 horse power. The vacuum was 22¼, and in a very hot day in August he got as high as 25 inches.

Mr. McConnell:—May I enquire the diameter of the cylinder, the stroke, and the pressure of the steam?

Mr. Cowper:—I think the high pressure cylinder was 7 inches diameter, and the other 13 inches.

Mr. Craddock:—The other was 14 inches. The stroke of the high pressure cylinder was 16 inches, that of the other 2 feet.

Mr. Cowper:—The pressure of steam was generally about 80 lbs.; but that varied.

Mr. Crampton:—I should like to know what proportion the condensing surface bears to the heating surface of the boiler.

Mr. Craddock:—I can furnish you with the substance of it. For instance, in an engine of 10 horse power the condenser would be a weight equal to 10 or 12 cwt. The larger the engine the less would be the proportionate weight; but I can say it would not exceed 12 cwt. for 10 horse power.

Mr. Crampton:—We generally suppose 9 feet of heating surface to generate steam for one horse power; and what I meant was, how many feet of cooling surface would condense this?

Mr. Cowper:—I think it was, as near as possible, 40 square feet to 41. I think Mr. Hall used with his water condenser 20 feet, and Mr. Craddock with his atmospheric condenser used twice as much.

Mr. Craddock:—I use about twice as much surface for giving out the same quantity of heat; but I think I shall be able to show, that I produced treble the amount of power from the same quantity of steam.

The President:—Have you any idea of trying it with locomotive engines as well as stationary?

Mr. Craddock:—That depends upon whether I obtain sufficient encouragement; but I think it would be found highly economical there; and hence I have an idea that some day or other it may be so applied.

Mr. Buckle:—Do I understand that you generate three times the quantity of steam that a common boiler does?

Mr. Craddock :— Certainly not. All I contend for is, that there is a larger amount of surface for the heat to act upon; and I conclude that I get a facility for generating steam which the common system is not capable of.

Mr. McConnell :—What is the proportion of the low pressure cylinder to the high pressure?

Mr. Craddock :—Six to one.

Mr. McConnell :—And the relative pressure of each when working?

Mr. Craddock :—That will materially depend upon the space which there is between the two cylinders for the steam to expand in. It is a matter of experiment only.

Mr. McConnell :—So far as your experience goes, what do you consider to be the relative pressure of the two cylinders?

Mr. Craddock :—As four to one.

Mr. McConnell :—Yes, that is the area; but the pressure?

Mr. Craddock :—Experiment will determine that.

Mr. Crampton :—I think he has to expand the steam six times when he has a pressure of 80 lbs. above the atmosphere. Is that so?

Mr. Craddock :—It is not fixed.

Mr. Crampton :—The expansion of steam is only relative. The general rule is, that at a pressure of 25 lbs. the steam is expanded five times. It appears to me that, in asking questions about the relative capacities of the small and large cylinder, we should always bear in mind the pressure of steam to be worked.

The President :—I should like to see the engine pumping water, in order to test it.

Mr. McConnell :—What is the relative consumption of your engine?

Mr. Craddock :—I have not carried my experiments so far as to form any rule: but where I derive the economy is chiefly in the expansion of the steam.

Mr. McConnell :—I think it is now some four or five years ago, since you first brought it under notice, and I was then anxious to ascertain what its economy was. Now I had hoped that having acquired more experience we should have been favoured with statements upon the subject, and also as to what Mr. Henderson's engine did as compared with yours. They were at work at the same place, and you had every opportunity of making the necessary experiments if you had wished it.

Mr. Craddock:—I have never directly asked Mr. Henderson; but I have many times thrown out a suggestion that it might be satisfactory to have some experiments made, and the suggestion was never acted upon.

Mr. McConnell:—In dealing with this question, we have to trust entirely to practice; and as to the economy of expanding steam to a certain extent, and that particular system of condensation, I do not think we are prepared to give a decided opinion. The best test would be, as the President has stated, that of pumping water.

Mr. Buckle:—Or grinding corn.

The President:—Or driving a locomotive engine.

Mr. Craddock:—I submit whether the indicator is not a sufficiently good test.

Mr. Crampton:—No question of it: but, when talking of economy, we must take into consideration, first, what does the boiler do? how much water do we evaporate for a given surface? When that is settled, then we may ask how much better is it than another? There is a question whether the two cylinders are better than a single one. Evidently a loss there is in the expansion of steam from the small cylinder to the large one, which you never can get back, and which you avoid by using a single cylinder. There may be a little more equal motion, but that is all you get. I tried them some years ago, and I found that you would lose something like 14 per cent., merely in the travelling of the steam from the small cylinder to the large one. It is however desirable that we should come to some settled opinion upon the subject. My impression has always been that there is a loss connected with the small cylinder. Put the same amount of steam in the large cylinder, cut it off, and you will do more work than if you first put it in the small one, and then sent it through to the large one.

The President:—There must be a loss. No doubt the Cornish engine does its work more economically from having only one cylinder.

Mr. Crampton:—What I want to know is, If the double cylinder is so good, *why* is it so? I cannot find by any experiments I have made, that there is any reason for it. There is, as I have said, a rather more uniform motion; and that little advantage I think we can get from a flywheel. We must lose a certain quantity of steam in going through the passage, and the gain of the more uniform motion is more than compensated by the greater economy in having the high pressure steam.

The President:—If you throw the steam into the large cylinder, and cut it off at high pressure, at a short portion of the stroke, you have that steam to expand over the other portion of the cylinder, before it is thrown into the condenser; this brings the high pressure and low pressure systems into action in the same cylinder, and you have as much power in that as you have in two cylinders.

Mr. McConnell:—There is one subject which we have not yet considered, and that is the advantage to be gained from using the revolving air-condenser, as compared with the ordinary jet-condenser of a stationary engine. There is certainly the advantage of using the same water and having no sediment, instead of drawing it up by an air pump and discharging it.

Mr. Craddock:—In reply to Mr. Crampton and the other gentlemen, I may state, that the practice of the profession is in my favour, as regards the use of the two cylinders. Time was however when these engines were tried and thrown aside. Let me call the attention of the meeting to the model before us. It is scarcely necessary to remind the members that in so small an engine the friction is considerable when first started; yet it had worked up to its speed with the steam cut off at 1-60th of the stroke; to get the same effect in one cylinder would cause great irregularity of motion. Another thing which I have found in the course of my experience—which has been considerable, having been engaged ten years in this matter, seven of which have been devoted in a great measure to experimenting—is, that those experiments with respect to the relative advantages of the double and single cylinder have proved to me, that by admitting high pressure steam direct from the boiler into the cylinder a considerable portion of it becomes condensed by coming into contact with the comparatively cold metal of such cylinder; the water resulting therefrom being in contact with the metal of the cylinder does, when placed in communication with the condenser, again assume the form of steam, which passing to the condenser uselessly carries away much heat from the boiler to it, without producing mechanical effect. I suggest that a more conclusive test than that of indicator figures, to which Mr. Crampton has alluded, will be that of two cylinders, one of which could be readily thrown out of action; such engine being connected with the same boiler, expanding the steam to the same extent, and performing the same work, the steam and coal required in both cases being accurately weighed. I have made experiments which are perfectly conclusive to my own mind; and I hope shortly to be able to

give you an invitation to investigate experiments which will be equally satisfactory to yours.

Mr. McConnell :—There is more than the question of the two cylinders involved in this. There is another principle, and if Mr. Craddock would pay attention to that, it might afford a great deal of information. I allude to the principle of condensing by air, in contradistinction to our ordinary way of condensing by a water jet. If there is economy in that, we get this result, that we have pure water; and we all know the benefit of that in the working of a steam engine. I merely suggest this, that Mr. Craddock may bring forward at a future period the results of this principle, as well as the advantages it may afford in the generation of steam. It appears to me that the condenser is most valuable for marine purposes.

Mr. Craddock :—The advantages of the condenser for marine purposes may be stated in a few words,—it would ensure water free from deposit, thus rendering tubular boilers practicable, which enable us to generate high pressure steam with safety; and thus by carrying out the expansive principle, with other advantages consequent thereupon, a saving of two millions annually, in the steam navy alone, would be effected.

Mr. Jackson :—I have for many years looked upon double cylinder engines as compound machines. From the manner in which Mr. Crampton has discussed this matter, it is evident that he could throw some additional light upon it. I therefore beg to move, "that this meeting will esteem it a favour if Mr. Crampton will prepare and lay before the next meeting a paper and diagrams descriptive of the experiments made by him, on the comparative merits of the double and single cylinder systems." The motion having been seconded was carried unanimously.

Mr. Crampton assured the meeting that it would give him great pleasure to do anything he could to elicit information on the subject. He had made some experiments eight or nine years ago, and he would be happy to go into the question again.

The next Paper, by Mr. Peter Rothwell Jackson, of Manchester, was read by Mr. Fothergill :—

ON A HYDRAULIC STARTING APPARATUS.

Various contrivances for connecting heavy machinery with and disengaging the same from the prime mover, without producing those sudden shocks which the use of ordinary clutch-boxes occasions, to the serious injury of both the article under operation and the machinery itself, have of late years been made the subjects of much enquiry. The principal ones in use are those invented by Mr. John George Bodmer, and introduced in various bleach-works in the neighbourhood of Manchester, where they are used in connection with the heavy mangles and callenders to great advantage. Mangles and callenders requiring from 30 to 40 horse power are, by this apparatus, connected with and disengaged from the engine, without stopping the same, and without any perceptible shock or noise being produced.

Mr. Bodmer effects his object by means of levers and knee-joints acting upon a series of segments lined with copper, which are brought into or out of contact with the internal or external surface of the rim of the driving wheel, thereby connecting the machine with or disengaging it from the driving shaft.

Now the author of this paper has thought that in many cases water, steam, or gas could be more easily and advantageously applied to force the segments against the rim; and he is about, with reference to the accompanying drawing, to explain a starting apparatus, in which water is employed as the medium of conveying the power to press the segments against the rim of the driving wheel.

The bevel pinion 1, Fig. 1, is supposed to be connected with the engine, or other prime mover, and gears into the bevel wheel 2, to which is cast a rim 3, which is turned internally. The wheel 2 turns loose upon the shaft 4, being lined with a brass bush 5; the shaft 4 however is provided with the four projections 6, through each of which a hole is bored, the centre lines of these holes lying in one horizontal plane, and meeting in one common central chamber 7. Into these holes the four rams 8, which are respectively cast of one piece with the blocks 9, are fitted; the blocks 9 being lined with copper, and turned so as to fit the internal surface of the rim 3. Supposing now that the machinery which is assumed to be connected with the shaft 4 required to be started, hydraulic pressure is applied to the rams 8, by pressing the ram 10 down upon the column of water 10* within the shaft 4 and the chamber 7, by means of the flywheel 11 with its nut 12, and the

screw 13, which forms one piece with the ram 10; the ram 10, nut 12, and screw 13 being guided and supported by the brass box 14, which is screwed into the upper end of the shaft 4. It is evident that on the ram 10 being thus pressed down, the rams 8 will gradually and simultaneously press the segments 9 against the internal surface of the rim 3, with a power proportionate to the force applied at the circumference of the flywheel 11, until the friction produced by such pressure shall be equal to the resistance of the machine to be set in motion. The machine will therefore gradually assume the velocity which, according to the speed of the driving shaft, it ought to have; at the same time that any extraordinary momentary resistance, such as might be supposed to occur occasionally in rolling mills, or other machinery of a similar nature, instead of causing the wheels to break, will have a tendency to make the rim 3 to slip on the segments 9 until the obstacle be removed or overcome.

In order however that too great a pressure may not be applied to the rams 8, the ram 10 and screw 13 are perforated with a small opening 14*, the extremity of which is closed by a valve 15, acted upon by a spiral spring 16, encased in the brass box 17, which is screwed to the top part of the screw 13; so that if at any time the pressure exerted upon the rams 8 should exceed that to which the spring 16 is regulated, the water would lift the valve 15, and escape through it into the box 17, and through an opening in the lid of the latter into the atmosphere, until the balance of the pressure was again established.

On the segments 9 requiring to be brought out of contact with the internal surface of the rim 3, it is only necessary to hold fast the flywheel 11, inasmuch as the screw 13 has a right or left thread cut upon it according as the shaft 4 turns either to the left or the right, and the rams are therefore immediately relieved, whereupon the machine stops.

It may be observed that the vacuum which is created in the column 10*, by the withdrawal of the ram 10, will in most cases be sufficient to cause the segments 9 to recede from the surface of the rim 3; otherwise that effect might be produced by the application of springs, or an elastic hoop.

The rams 8 and 10 are made good with press leathers in the ordinary way of hydraulic presses.

The paper was accompanied by a large drawing.

In answer to a question, Mr. JACKSON stated that he had had the apparatus at work for two or three months, and it had acted very well, and he thought that by it he had saved some horse power.

The PRESIDENT :—I think it is very ingenious, and calculated to be useful.

Mr. MCCONNELL :—I observe that the regulation of the pressure upon the segments is provided for by an escape valve at the top. It is in fact a safety valve for preventing a greater pressure of water upon the rams. What I want to ascertain is, whether you can by any means so determine the pressure, that you can vary it according to the necessity of the case.

Mr. JACKSON :—You have only to screw the box down tighter.

Mr. MCCONNELL :—Yes, but you may screw it down so tight as to snap the teeth.

Mr. FOTHERGILL :—There is a spring at the top.

Mr. MCCONNELL :—That is what you may call a safety valve.

Mr. JACKSON :—Yes, and it will act the moment the pressure becomes too great.

Mr. MCCONNELL :—But supposing it do not act (I am looking forward to that), in such a case you would be worse off than before, for trusting to a self-acting principle.

Mr. JACKSON :—By pressure upon the wheel the man can tell entirely by the feel.

Mr. MCCONNELL :—I think it is a clever thing altogether.

Mr. FOTHERGILL :—Mr. Jackson has arranged it in a similar manner, as regards the pressure of the safety valves in locomotives, where the spiral spring is introduced. There is a certain spring, and a certain amount of resistance is necessary to allow the water to escape. If the person screws it beyond a given pressure, then this valve opens.

The PRESIDENT :—And lets the water out?

Mr. FOTHERGILL :—Yes; therefore it is self-acting from beginning to end. It is very ingenious, and highly valuable.

Mr. CRAMPTON :—In case any grease should get in, I think you would require a regulator.

Mr. FOTHERGILL :—A greater amount of power would then be required to be transmitted, in order to turn the rollers of the rolling

mill; but then there is a regulation to the pressure, for it discharges itself when it exceeds a certain force.

Mr. CRAMPTON:— May I ask what the objection is to the cones?

Mr. SLATE:—They get oval, and consequently jam themselves.

Mr. McCONNELL:—They begin to twist round, and get unequal in the surface, and only bear upon the point.

Mr. FOTHERGILL:—There is a great deal of lateral action where there is a cone.

Mr. BUCKLE:—There is considerable lateral action, and the pressure is directed endways; besides there is a danger of sticking.

Mr. SLATE:—I have seen a cone stick several times a day, and no ingenuity could avert it. The remedy was to put in a little oil, after which it would go on, but only for a day or two.

Mr. COWPER said he had had the conical clutches in use many years, and if the angle be made just below the angle of friction, the pressure is moderate, and the cones do not stick.

Mr. SLATE:—You will always find it more or less difficult to define the angle of friction. The size of the cone I spoke of was fourteen inches at the top; I do not exactly recollect the taper, but it could easily be thrown out; it would break cast iron spindles of two or three inches diameter.

Mr. CRAMPTON:—I was yesterday in a large dredging boat, where the cone had been put in by Mr. Humphrys of London, one of the council of our Institution; the cone was four feet in diameter, but the principle had been altered, and it answered beautifully. Mr. Humphrys had made one before, but had not got the correct angle of friction, and he had put this one in, which he conceived to be right, and when I saw it it was going on well. Mr. Humphrys has a scheme for taking off the end pressure.

Mr. COWPER:—I can appreciate that. The first cone I made was not a correct angle, and it stuck fast; it was 1 in 13; I have since made them 1 in 6 and $6\frac{1}{2}$ and $6\frac{3}{4}$, and they work very well, but they must have some end pressure.

Mr. McCONNELL:—There is no way of taking off the end pressure without putting on a side pressure, in order to get the requisite grip to turn the shaft, and that I conceive is the point where great advantage will be gained by Mr. Jackson's mode; that he, without any pressure at all, by this expanding mandril (if we may so term it), suits the inner cylinder to the surface, or rather the inner cone to the

surface, and the only point not clear to me was the safety valve; if it acts like the one described, and gives way just before the point of breakage, then we have everything we desire. There is a great objection to the ordinary cone, take what angle you will. If a piece of grit or too much oil get in, you are sure to have an accident.

Mr. Jackson:—I have never seen a cone which would drive anything like the power that this is calculated for. The rollers were 3 to 3½ horse power, and I have never seen a cone which would turn 3 horse power.

Mr. Crampton:—The one I refer to was about 35 horse power.

Mr. Jackson:—Another objection to the cone is that the surface does not wear equal.

Mr. Cowper:—The cone I speak of did wear equal.

Mr. McConnell:—I think we are much indebted to Mr. Jackson for the introduction of this apparatus; it is very ingenious, and I think it possesses many advantages; I think that he is entitled to the thanks of the Institution. There can be no two opinions as to his plan being quite superior to the ordinary cone; and I beg to move "that the thanks of the meeting be given to Mr. Jackson for introducing the subject to our notice." The motion was seconded by Mr. Cowper, and carried unanimously.

Mr. Fothergill:—I think a communication of this kind ought to be made known to those of our members who have not had an opportunity of attending this meeting. I beg leave therefore to move "that Mr. Jackson's paper and accompanying drawing be printed and circulated among the members." The motion having been seconded was unanimously carried.

The President then called upon Mr. Buckle to read a paper by Mr. Edwin Chesshire, of Birmingham.

Mr. Buckle:—I beg to claim a little of your attention while I endeavour to describe what appears to me to be a very useful appendage to a railway train. I am of opinion that this apparatus, accompanied by the spiral brake of our worthy President, will do all that can be done in averting the serious calamities attending the casualties on railways. The following is Mr. Chesshire's paper:—

ON CHESSHIRE'S SAFETY BUFFER.

The object of this invention is to lessen the injurious effects of collisions on railways, both to the passengers and the carriages of the train. To attain this, it is proposed to place in the rear of each train a strong van, which may be made applicable if thought desirable for the conveyance of luggage or goods. In the front of the train the tender is proposed to answer the same purpose as the van behind; the centre of gravity of each to be nearer the level of the rails than that of the other carriages.

Each carriage is to be supplied with a strong moveable rod of iron, either a tube or a solid, supported in the centre of the under framework by bearing sockets. The rod is intended to have simply an endway motion. Each safety buffer is to have a head at each end similar to the present side buffers, but the heads of the safety buffers are not intended to act against each other except in cases of collision. When the carriages are screwed up into their ordinary travelling state, there will still be a space between the safety buffers of some few inches, to permit the usual action of the side buffers, without acting at the same time upon the safety buffer.

In the van in the rear, and the tender in the front, the safety buffer will be fixed so that in either case it cannot have an endway motion further than being fixed against strong elliptical springs will permit of, if such springs are thought desirable.

It will be perceived that, in case of a collision, the moment the side buffers have been driven home to the extent of the interval between the safety buffers, the force of the collision will be instantly imparted to them, and be conveyed by that means from buffer to buffer to the further extremity of the train, either to the van in the rear or the tender in the front, according as the collision may happen to occur.

The safety buffer would, it is fully expected, have also the effect of preventing the carriages from riding one on the top of the other, which was the case in the Wolverton, the Nottingham, and other collisions, and the cause of so much destruction.

After the paper had been read, a series of experiments were made on a model railway erected at the back of the theatre. A train of carriages with the safety buffers was started from one end of the line,

and another without them was set in motion from the opposite end. A collision took place in the centre of the lino, and the carriages to which the safety rods were fixed remained upon the rails, with the exception of the luggage van behind, while those without the rods were scattered about in all directions. The shock was received by the van, which, as Mr. Buckle stated, was intended to be loaded with heavy luggage.

The PRESIDENT :—I think one of the points must be to take the mass and the momentum, to see what the velocity is. It will surprise some of you who have not paid attention to these matters to know that, supposing a train starts with sixty waggons, the last waggon receives the greatest shock upon starting. The question is therefore whether, without these safety buffers, the last carriage does not get the shock. The momentum or force has to be stopped somewhere, and cannot be got rid of.

Mr. BUCKLE :—The shock is conducted to the last carriage, which Mr. Chesshire proposes to have filled with luggage. The public require that some experiments should be made with the view to avert the serious calamities occurring on railways, and this invention should at least be put to the test.

The PRESIDENT :—The momentum must be taken up by something, and what is that something to be? You may try any scheme, but you cannot prevent the momentum of the matter coming upon the engine in the event of a backward shock.

Mr. McCONNELL :—I am afraid there are practical objections to this invention, which would render it difficult to get the shock transmitted throughout the train. We know the difficulty there is to get the ordinary buffers all ranged horizontally on a line with each other. Now if this rigid bar is not transversely and horizontally in a line, I imagine it would not have the effect of transmitting the shock in the manner intended by Mr. Chesshire, and it would be liable to bend; so that, in order to have this scheme to act perfectly (supposing the principle to be right), it would be necessary that the carriages should be all of one height, and they must be in a straight line when the blow reaches them to be of any effect. On a curve the tendency would be to throw off the middle of the train, and not the end carriage at all, as forces go in a straight line. No doubt the last carriage receives the shock, and the centre carriages escape comparatively unscathed; but there are so many practical difficulties connected with carrying the plan into operation, that, looking at the number of cases in which it

might be useful, and those in which it would not act as it is intended, it appears to me very problematical whether it ought to be brought into use.

Mr. Fenton :—A curve is the place where the principle would not act, and I believe that that is the most likely part of a railway to meet with collisions.

Mr. Chesshire :—That collisions occur most frequently on curves I believe is an error. I have been in conversation with an eminent engineer, who stated that the very place where he would anticipate a collision was the very place where it did not occur. They rarely happened on curves, because there the driver was more particularly on the look out.

Mr. Joseph Wright :—An objection which I see to Mr. Chesshire's scheme is, that all the carriages must be constructed upon the same principle; for if any one has not that apparatus, it becomes inefficient, the connection having been broken.

The President :—Yes, there are now many thousands of carriages at work, and it would be a serious matter to alter them all.

Mr. Wright :—Besides, I do not see a proper mode of connecting the carriages. It is necessary that the ease of the carriages should be consulted, as well as the safety; and therefore that the carriages should be screwed up tight; and I think the means of connection is destroyed by the longitudinal rods. With them you cannot apply the screw in the same way as at present. But suppose the collision take place upon an incline, and the last carriage is thrown back, as proposed, where will it go to?

A Member :—To make another collision.

Mr. Wright :—Yes, most likely it will; I do not think the plan is sufficiently matured at present to be brought into practice; or rather, I may say, it is too late to bring it into practice, because there are so many thousands of carriages now in use, that the alterations would involve an expense which no company would incur: and in cases of lines running into each other, such as the London and North Western, where there are nine different lines intermixed, the plan would be impracticable.

The President :—I think there would be great difficulty in bringing the invention into use on old railways.

Mr. Buckle :—Have you ascertained the cost of fitting up the apparatus?

Mr. Chesshire :—It would be about £6 or £7 per carriage.

Mr. Wright:—Then there are between sixteen and seventeen thousand carriages in operation on the London and North Western, and if you multiply that by seven or eight you will find that the great cost raises an objection which it will be difficult to get over, particularly at the present time, when the companies have no money to spare.

Mr. McConnell:—I think public safety is the first consideration; and a little expense ought to be borne, provided it is to obtain that object; but the objection which Mr. Wright has stated would operate very strongly against the adoption of the plan before the meeting, unless there was some government enactment, binding every company to adopt it. We ought however to look at it as a question of principle. It is the duty of those who are entrusted with the practical working of railways, to point out, as far as experience guides them, the difficulties that would be met in carrying any scheme into operation; and it is very clear that in adopting this buffing apparatus it would be necessary to alter the mode of connecting the carriages, and that must not be done so that when you come to adopt it you may find, that although you have a problematical advantage one way, you have a decided disadvantage the other; and if the rods prove to be too light, and bend or swerve, I can easily imagine that the consequence would be the total destruction of every passenger in the carriage where the rod broke. I believe that every one would be smashed to atoms; because into that particular carriage would be landed the effect that was intended for the last carriage. Supposing also a collision to take place in the usual way, the present buffers would receive the shock in different proportions.

Mr. Wright:—The amount of force is expended before all the buffers are brought into action. There used to be a stationary buffer at Euston station, and on a recent occasion a train went too far, and ran into it. The check was received by the first carriage, and by the time the shock reached the last, its power had been so expended that the passengers in it knew nothing of the collision.

The President:—I was once on a train where two men were killed by a collision, and in the fourth and fifth carriages the shock was not felt in the least.

Mr. Chesshire:—I think the safety of the public positively demands that something of the kind I propose should be brought into practice. I had an interview at the board of Trade with Lord Clarendon and General Pasley, and submitted my model to them, of which they approved. I am quite satisfied that if this Institution

were to recommend my improvement, every railway company in the kingdom would take it up. As to the objection of its interfering with the couplings now in use, I would say, why confine ourselves to these particular couplings? I am confident better ones might be introduced.

Mr. McConnell:—Mr. Chesshire should not lose sight of this, that if a train comes up, and it is proposed to transmit its force backwards through these buffers, it has nevertheless the momentum of all the other carriages coming up to it. It would transmit its force through the rod to the last carriage, which, naturally enough, would break its couplings and fly back; but still there is the whole momentum of the train at 30 miles an hour coming up against the engine, which you would stop so suddenly.

Mr. Peacock:—Supposing a train of carriages to run against a dead stop, or a stationary buffer, at the rate of six or eight miles an hour, the first carriage of course stops momentarily, the second carriage receives a less amount of shock, the third still less, and so on, till towards the end of the train it becomes insensible. That is the effect of our present system of buffers. The only difference between them and Mr. Chesshire's is this; that his method would communicate the shock to the first and last passengers at the same time, instead of distributing it gradually, so that we should lose the advantage afforded by the present system.

Mr. Cowper supported the view taken by Mr. Peacock. The invention, he said, amounted only to stiffening the under frame of the carriages.

Mr. Chesshire reminded the meeting that he did not contemplate interfering in the least with the side buffers. His plan would admit of the side buffers of all the other carriages acting, because the shock would be so instantaneous that the last carriage would be disconnected before the others came in contact.

Mr. Fothergill:—The buffers would not, I think, be of any use with these rods, because they would not come in contact before the force was expended throughout the whole of the train, and you ought to fix upon a good distance for the buffer to work in satisfactorily.

Mr. Ramsbottom:—With the present system, if the buffers are supposed to have a range of 12 inches, we do not get a dead shock; the first carriage will have to move through a space of two feet before its motion is arrested; the next carriage will have four, the next six, and so on; and we can easily suppose the continued action of the

whole of the buffers to be equivalent to putting on a break for two or three hundred yards. But if we look at the action of the safety rods, it is clear that the shock must be conducted simultaneously to the whole of the carriages at one time, and the whole velocity of the carriages resisted in the space of one foot; making the shock much more severe in proportion, if the ordinary buffers are not intended to go home till the rods come into play.

The PRESIDENT:—You do not stop a bit of the momentum, but only carry it to the end of the train.

Mr. CHESSHIRE:—It is transferred to the van, and there it is expended.

Mr. McCONNELL:—I think Mr. Chesshire had better let this matter now be ended here. We seem not to agree upon the subject, and I would recommend him to have a conversation upon the matter privately with the Council. They may perhaps be able to convince him that there are objections to his plan which he does not see at present.

Mr. CRAMPTON:—I have been endeavouring to make myself acquainted with the invention, and though I confess I do not feel very clear about it, yet the result of the experiment which we have witnessed occurs to me, and I really think there is something in it. I think it is worth our attention, and we ought to look at the thing in a scientific point of view, in order to learn whether it is right in principle; because if it is, the difficulties made by Mr. Wright ought not to stand in the way.

The PRESIDENT:—I want to get something to take up the momentum, and Mr. Chesshire has not managed to do that.

Mr. RAMSBOTTOM:—The shock cannot be received fairly if it is received either above or below. There will be a tendency to throw the train off the line. If the shock is distributed over a great space of matter gradually, it is divided, and the less severe will it be to the passengers.

Mr. CHESSHIRE thanked the meeting for the very patient attention they had paid to the subject; but he was still of opinion that, by the plan he proposed, the first and great shock must be conveyed through the safety buffers to the van behind the train, leaving the carriages uninjured.

Mr. FOTHERGILL then read the following statement of facts relative to Banks' Patent Steel Tyres, for steeling the tyres of railway wheels:—

BANKS' STEEL TYRES.

After an experience of five years, it is ascertained that the cost and durability of Staffordshire tyres steeled on this plan, as compared with the Low Moor tyres, is :—

Low Moor (Yorkshire); three feet Wheels.

Four tyres of 3 cwt. each = 12 cwt. at 22*s*.	£13	4	0
Putting on the tyres ready for work	8	0	0
Twice turning up, after wearing hollow	1	0	0
	£22	4	0

Suppose these tyres to run 50,000 miles on an average, it would give 50,000 miles at a cost of £22 4*s*.

Staffordshire; three feet Wheels.

Four tyres of 3 cwt. each = 12 cwt. at 12*s*.	£7	4	0
Putting on the tyres ready for work	8	0	0
Steel for steeling one set, 1½ cwt. at 42*s*.	3	3	0
Wages, turning grooves in wheels...	0	10	0
Do. inserting the steel	0	10	0
Do. turning up after steeling	0	10	0
Do. drilling and rivetting...	0	7	6
	£20	4	6

These tyres are proved to run 18,000 miles before steeling, and 100,000 after steeling; making a total of 118,000 miles at a cost of £20 4*s*. 6*d*.

The 50,000 deducted from 118,000 leaves 68,000 miles in favour of the Staffordshire tyres, besides a saving in cost of 39*s*. 6*d*. per set; the cost of the Low Moor tyres being 8*s*. 10½*d*. per 1000 miles, whereas that of the Staffordshire is only 3*s*. 5¼*d*. The tyres are not of course worn out alike on all railways; but on those lines where the iron tyres will run more than is here stated, the steel tyres will run more in proportion, and the plan is attended with no danger whatever.

This statement shows only the advantage of steeling the tyres once; but many have been steeled a second time, after having run the above mentioned distance. The cost of the second steeling is £5 per set, for which they will run 100,000 additional miles; making a total of 218,000 miles at a cost of £25 4*s*. 6*d*., or 2*s*. 4*d*. per 1000 miles.

The general objection made is that there will be much trouble in carrying out the plan; but such is not the case. When the wheels require turning up, they must be taken from under the carriage or wagon; and when so taken, the cutting of the grooves in the tyres for the steel will not cost more than 5*s.* 0*d.* per pair in wages. When the grooves are turned, one smith and three strikers will insert steel segments into ten pairs of three feet wheels, in one day of ten hours; after which, turning up the steeled wheels will take very little more time than turning up without steeling; which proves that the trouble will not be so great as is imagined, and nothing, when the durability and saving which is effected by the tyres being steeled on this plan is considered.

The statement was accompanied by a recommendatory letter from Mr. Jenkins, locomotive superintendent of the Lancashire and Yorkshire Railway, dated 28th January last. It stated that these patent steel segments had been inserted in the wheel tyres of the engine "Oldham," and that she had run 58,866 miles with them when the crank axle broke; the wheels were then taken off, and not again used until they were put to the engine "Queen," on 12th November, 1846. From that time to 31st December, 1847, they ran 29,482 miles, making a total of 88,348 miles; and should no accident occur, Mr. Jenkins is of opinion that they will run 40,000 or 50,000 miles more. He believes that there is a great saving of expense in using them.

The President said he supposed it was generally known that these tyres did wear well. Some of them were liable to a great loss, but on the whole he thought they made a good wheel.

Mr. McConnell thought they required to have a strong tyre in the first instance, in order to have sufficient body to prevent the widening of the grooves in which the steel is inserted, and that they also required to be put in very carefully.

Mr. Peacock said he had tried a great number of them, especially upon tenders: indeed he had some which worked five feet wheels, and they answered very well. The principal trials however had been on tenders, 3 feet 6 inch wheels, on the Manchester and Sheffield Railway, the gradients of which were very heavy, and he found that on an average they were obliged to change the tender wheels about once in four

months. The first which were tried with Banks' mode of steeling ran twelve months. This proved that they were a great saving, for tenders especially. They had had some which ran nearly 30,000 miles under an engine, and they worked very well.

Mr. McConnell believed there was economy in them, and where there was a great deal of breaking in the wheels, and skidding, the steel would stand much better. But he would really prefer a good tough iron tyre. One of the segments falling out might neutralize a great deal of the good effect.

A Member said he had seen an instance of a segment breaking off, and there was no bad effect.

Mr. Ramsbottom said an impression had gone abroad, that Banks' tyre pretended to make a bad wheel good; but the wheel must be good in itself. Some experiments were about to be made to test how far iron segments would be preferable to steel in this respect, as the same body of iron could be made closer in the grain and more durable. At some future time, if thought desirable, he would be prepared to lay before the Institution the result of those experiments.

The business having been brought to a conclusion, the President expressed himself well pleased with that evening's discussions, and he hoped that the next meeting would prove as interesting. Mr. McConnell's long expected paper "On the balancing of Wheels" would be brought forward on the next occasion; and also one from himself "On the Fallacies of the Rotary Engine." That engine never had been and never could be used to advantage, and his paper would show the reason. It had been tried in Birmingham, and of course without success. Mechanics ought to know the reason of that. Very erroneous notions existed on the subject of the crank. The crank, he considered, was the most beautiful and efficient motion, and the idea that power was lost by it was a great mistake. It was in vain to attempt to evade the great law of mechanics,—a pound for a pound, a pound of weight for a pound of power; and no person who knew the law would think of opposing it. At the next meeting he would endeavour to explain the crank to the members, and to make them understand it, although many members of the Institution no doubt understood it well.

At the suggestion of several members, it was agreed to alter the time of meeting from five p.m. to four p.m.

Messrs. Cowper and Fothergill, as a Committee of the Council, opened the ballot returns, and declared the following gentlemen elected Members and Honorary Members :—

MEMBERS.

John Ashbury, Albion Carriage Works, Manchester.

Thomas Auster, Messrs. Auster and Smith, Easy Row, Birmingham.

William Bagnall, Messrs. Bagnall and Sons, Gold's Hill Iron Works, Westbromwich.

William Baker, Engineer of the Shropshire Union, Shrewsbury and Birmingham, and Birmingham Wolverhampton and Stour Valley Railways, 28 Waterloo Street, Birmingham.

Charles De Bergue, Engineer, 9 Arthur Street West, London Bridge, London.

J. O. Butler, Messrs. Butler and Co., Kirkstall Forge, Leeds

James Carstairs, Engineer, Dewsbury.

Edward Corry, Messrs. Adams and Co., Fairfield Works, Bow, London.

J. C. Craven, Superintendent of the London Brighton and South Coast Railway Brighton.

Robert Crosland, Union Foundry, Bradford.

William W. Cutts, Rockingham Works, Sheffield.

Christopher H. Dawson, Low Moor Iron Works, Bradford.

Charles Denton, Engineer, Bromley New Town, Bow Common, London.

David Elder, Messrs. Robert Napier and Co., Engineers, Glasgow.

Douglas Evans, Engineer, Warsaw.

George Allen Everitt, Kingston Metal Works, Birmingham.

Benjamin Gibbons, Iron Manufacturer, Shut End House, near Dudley.

Nathan Gough, Engineer, Manchester.

James Gow, Locomotive Superintendent of the Leeds and Thirsk Railway, Leeds.

Thomas Grainger, Engineer-in-chief of the Leeds and Thirsk, and the Leeds Dewsbury and Manchester Railways, 119 George Street, Edinburgh.

James Gray, Steel Manufacturer, Sheffield.

Charles Green, Patent Brass Tube Works, Leek Street, Birmingham.

William Hartree, Messrs. John Penn and Co., Marine Engine Builders, Greenwich.

Robert Hawthorn, Messrs. Hawthorn, Locomotive Engine Works, Forth Banks, Newcastle-on-Tyne.

Robert Hughes, Superintending Engineer of the Steam Department, Admiralty, London.

Richard William Johnson, Bromsgrove Railway Carriage and Wagon Company, Bromsgrove.

William Johnston, Engineer of the Glasgow and South Western Railway Glasgow.

Thomas William Kinder, Bromsgrove Railway Carriage and Wagon Company, Bromsgrove.

William L. Kinmond, Messrs. Kinmonds and Co., Wallace Foundry, Dundee.

Samuel John Knight, Messrs. Knight and Cumming, Waterside Iron Works, Maidstone, Kent.

Edward Lawson, Hope Foundry, Leeds.

Benjamin Lewis, Messrs. F. Lewis and Sons, Stanley Street Works, Salford.

Sir John Macneill, Engineer-in-chief of the Principal Irish Railways, 28 Rutland Square, London.

John Matthew, Messrs. John Penn and Co., Greenwich.

Edwin Marshall, Railway Carriage Builder, Birmingham.

Samuel North, Locomotive Department, London Brighton and South Coast Railway, Brighton.

John Penn, Messrs. John Penn and Co., Greenwich.

Robert B. Preston, Messrs. Fawcett and Preston, Engineers, Liverpool.

Edward Rishton, Engineer, Leeds.

James F. Roberts, Locomotive Superintendent of the Waterford and Kilkenny Railway, Waterford.

Henry Robertson, Engineer-in-chief of the Shrewsbury and Chester, and Shrewsbury and Hereford Railway, Chester.

John M. Rowan, Messrs. Rowan and Co., Engineers, Atlas Works, Glasgow.

Charles Sandford, Messrs. Sandford and Owen, Phœnix Forge, Rotherham.

William Prior Sharp, Messrs. Sharp Brothers, Atlas Works, Manchester.

Henry Sharp, Messrs. Sharp Brothers, Atlas Works, Manchester.

Archibald Sinclair, Messrs. Adams and Co., Fairfield Works, Bow, London.

Norman Henry Smith, Messrs. Auster and Smith, Easy Row, Birmingham.

James Stirling, C. E., Edinburgh.

Robert Thornton, Locomotive Superintendent of the North British Railway, Edinburgh.

HONORARY MEMBERS.

William Charles Alston, Elmdon Hall, near Birmingham.

William Eagle Bott, Secretary of the Leeds Dewsbury and Manchester Railway, Leeds.

Henry Cole, Keeper of the Public Records, Branch Record Office, Carlton Terrace, Westminster.

Samuel Crosby, Coleshill Street, Birmingham.

Henry Heane, Solicitor to the Shropshire Union Railways Company, Newport, Salop.

John Lord, Agent for the Zealand Railway Company, Birmingham.

William Overend, Barrister, 3 Paper Buildings, Temple, London.

C. P. Roney, Secretary of the Eastern Counties Railway, London.

PROCEEDINGS.

June 13, 1848.

A Special General Meeting of the Members was held in the Theatre of the Philosophical Institution, Cannon Street, Birmingham, on Tuesday, the 13th of June, 1848; J. E. McConnell, Esq., Vice-President, in the Chair.

The Minutes of the last meeting were read by the Secretary, Mr. Kintrea, and confirmed.

The Chairman stated that, in consequence of the unavoidable absence of the President, the paper "On the Fallacies of the Rotary Engine" would not be brought forward until the next meeting; it therefore fell to him to commence the proceedings, by reading his own Paper:—

ON THE BALANCING OF WHEELS.

The advantages derivable from balancing the wheels of locomotive engines and railway carriages and wagons are very important; and the object of this paper is to bring the subject more prominently before the members of the Institution of Mechanical Engineers, in order that the value of balancing railway wheels, and also all other machinery, may be properly understood.

There is a class of accidents which, from their frequent recurrence and the evil consequences resulting therefrom, require the careful attention of engineers connected with railway business: I mean those accidents where, from a rapid rate of travelling, the oscillation progressively increases in violence, and in a jumping or jerking motion, causing the engine or carriages to jump from the rails; and I hope to

demonstrate that the origin of these frightful cases, causing loss of life and immense damage to the property of the railway companies, is simply the absence of a proper equilibrium in the movement of the wheels and machinery of the engines and carriages; and although there may have been, in one or two instances, a fault in the rails or condition of the permanent way, even that was produced by the irregular working of the same machine on previous occasions.

Before proceeding to explain the results of many experiments and the rules which they afford, I wish to mention that the merit of instituting the first systematic enquiry into the effects of balancing wheels is due to Mr. George Heaton, of Shadwell Street Mills, Birmingham, who, since his attention was drawn to the subject in the year 1810, has laboured earnestly to effect a proper plan of balancing wheels in all kinds of machinery. Here it may not be out of place to read a description of the origin of his investigations, as detailed by Dr. Melson when delivering a lecture on Physical Mechanics, at the Birmingham Philosophical Institution, in the year 1842; possibly in the room in which we are now assembled:—

"It was in the year 1810, whilst Mr. Heaton was employed at Combe Abbey, by the late Earl of Craven, in a part of his lordship's establishment kept for the amusement of himself and his visitors in the practice of mechanical pursuits, as turning, sawing by circular saws, ornamenting by the aid of rose engines, &c., the covers of snuff boxes and other fancy articles, that, finding his hand power insufficient, his lordship determined to have a small steam engine erected, of sufficient power to drive the lathe, &c., at the requisite speed. The engine having been put up, his lordship and many of his visitors were surprised to find, that when one of the lathes was urged to a speed of about 600 revolutions in the minute it began to shake, and shook to such an extent as the speed was augmented as to raise the whole lathe and frame from the floor upon which it was placed. Mr. Heaton was of course consulted as to the cause of this agitation, and he attributed it unhesitatingly to the fact that the revolving parts of the machine, the pulleys, were not equal in weight on both sides of the centre. The lathe was of beautiful workmanship, made by one of the best makers in London, and the pulley suspected of the fault was made of rosewood, on which was fixed a dividing-plate. Now it was

probable that the texture of the wood being closer on one side than on the other when *dry* was the cause of this inequality in the weight. Mr. Heaton had immediate instructions to remedy this defect if possible, and he accomplished it in the following manner: —he bored a hole on the light side of the pulley 3½ inches from the centre, and introduced into it 9 ounces of lead, which was the quantity required to make the pulley perfectly in balance. The lathe was now again set to work, and at a speed of 600 revolutions per minute or any other speed requisite for its work it was perfectly free from shaking. This rocking motion was now illustrated on a large model, whose axis was of the breadth of the ordinary railway gauge, and its two revolving rods of the length of the diameter of the wheels of a locomotive engine. Being unequally balanced, and made to revolve by a weight of 6 lbs., it exemplified the rocking motion of the lathe. The same motion, Dr. Melson observed, may also be noticed in some of the guide pulleys that are heavy-sided on the railways, where a rope is used to draw the train along, particularly when the train runs fast. Here several corrections of machinery, both of lighter and more ponderous construction, were severally detailed, in which Mr. Heaton had succeeded, by attention to this principle, in producing an equable motion, where before the most violent and unaccountable agitation had prevailed. One striking instance occurred in the latter part of last year: an application was made to the firm of Heaton Brothers, Shadwell Street, for instructions to remedy the evil attendant upon the working of a fan used for the purpose of creating a blast for melting iron; this fan had been set to work, but the steam engine by which it was driven was found incapable of getting it up to the required speed, which was about 1000 revolutions per minute, and when it approached that speed it shook the whole of the buildings, and shook itself loose from its bearings. To obviate this position of affairs, the proprietors removed it into another position, and propped it with strong timbers, which strong timbers had their bearing under a heavy wall. When again set to work it shook the whole place as before, and made so much noise that the proprietors were threatened with a prosecution for nuisance. At this critical juncture of affairs, Messrs. Heaton, having been consulted, immediately took the fan to pieces and found it 2 lbs. 8 oz. out of balance. The evil was rectified, and the fan restored to

its former position, short of the whole of its props, &c. The engine was now set to work, and was found capable of driving the fan the requisite number of times, the nuisance was removed, and the fan had never since displayed any disposition to move from the place where it was set. Here an important observation was made, to the effect that the outside of the wings of this fan, which was 3 feet in diameter, when running at 1000 turns per minute, does not travel quite twice as fast as the rim of the wheels of a railway train when the train is running at the speed of 30 miles an hour. The motion of the fan was now imitated on the large model, in which experiment the weights on the outside of the steel rods were not propelled at the rate of 15 miles an hour, although the effect was so violent; whilst at the same time the weights travelled at a uniform speed in each part of their revolution. This was not the case with the wheels of a railway train; for if a train were travelling at the rate of 30 miles per hour, the top part of the wheels would of course have a much greater motion than the centre. If then such an effect were produced by the model, when only 12 ounces out of balance, and only moving that 12 ounces at the rate of 15 miles per hour, what effects were we not prepared to expect from a railway wheel thrown forward at four times the speed, and where, as in many instances was the case, the wheels were each four times that much out of balance."

I could also, if necessary, instance several recent accidents on railways, resulting I believe from the same cause, and also from a want of balance of another description, to which I mean to direct the notice of the members of this Institution at a future meeting.

The more clearly to account for the great effects produced by balancing wheels, I have carefully noted the experiments made, in order to found some general principle by which they are to be regulated; and I find that the laws of central forces will afford the proper data. By the laws of central forces, when a body is made to revolve in a circle round some fixed point, it will have a continuous tendency to fly off in a straight line, at a tangent to the circle, which tendency is called the centrifugal force; and the opposing power by which the body is retained in the circular path is called the centripetal force, and both forces when taken together are termed central forces. Now it must be self-evident that the centrifugal forces of two bodies of

unequal weight, moving with the same velocity of revolution, at the same distance from the centre, are to one another as the respective quantities of the two bodies. Further, the centrifugal forces of two equal bodies which perform their revolution round the centre in the same time, but at different distances from it, are to one another as the respective distances from the centre. The centrifugal forces of two bodies which perform their revolution in the same time, and whose quantities of matter are inversely as their distances from the centre, are equal to each other. The centrifugal forces of two unequal bodies moving at equal distances from the centre, with different velocities, are to one another in the compound ratio of their quantities of matter and the squares of their velocities. The centrifugal forces of two equal bodies moving at equal distances from the centre, but with different velocities, are to one another as the squares of their velocities. The centrifugal forces of two equal bodies moving with equal velocities at different distances from the centre are as their distances from the centre. The centrifugal forces of two unequal bodies moving with equal velocities at different distances from the centre are to one another as their quantities of matter multiplied by their respective distances from the centre. The centrifugal forces of two unequal bodies moving with unequal velocities at different distances from the centre are in the compound ratio of their quantities of matter, the squares of their velocities, and their distances from the centre.

Without entering on the wide subject of central forces, which would require more space and mathematical reasoning than this paper can embrace, I shall now illustrate by a few examples on the models before the meeting the effects of wheels unbalanced and in balance.

In order to arrive at a correct principle of balancing wheels, it is only necessary to find out by a delicate apparatus,—such as by having the wheel suspended by the centres of a lathe, or other centres, so that there may be as little friction as possible in revolution, and then by tying a weight at the periphery of the wheel to overcome the inertia,—the difference required at one point more than another, necessary to place the wheel in perfect balance. This test is only necessary at four points; having first discovered the heaviest side, the opposite or lightest, and then the other two at right angles to these, proceed to place balance weights as required.

With engine wheels on a crank axle, it is necessary to attach all the rods and other appendages which increase the weight of the wheel in revolving, and consequently great care is necessary to place these parts in their natural position, as when at work.

It is a fact worthy of notice, that two wheels cannot be balanced on the axle at the same time. One wheel requires to be put on and fairly balanced by itself; and when properly adjusted, the other is added; and precisely the same process must be again performed.

In connexion with this subject, I have observed a singular effect produced by a want of balance, which may be very interesting. In the year 1846 a number of powerful merchandise engines were delivered by various makers to the London and North Western Railway Company; and so far as the plan and construction of the engines were concerned, the company was satisfied; but in a short time a flat place was found on the tyre of the wheels, exactly opposite to the crank. Many reasons were assigned for this, but none were correct; and the matter was submitted as a fatal objection to the engines. I was consulted on the subject, and at once gave it as my opinion that the sole cause was a want of balance. An engine was put in balance; and the cause being removed, the engines were again restored to favour.

The saving in power by the wheels being put in balance is very considerable; and I know from experience, that were this subject taken up with a desire to put all wheels in balance as perfect as possible, 10 per cent. of traction force would be saved.

I have now to introduce to the meeting a small model showing the advantages of another kind of balance, which in its results will I believe do as much for the prevention of accidents as even the balancing of wheels: I mean the balance to the momentum of piston and rod. As it will however form the subject of a future paper, I shall merely submit the model to the members: and I trust they will give the matter their earnest consideration.

The following is a Table of experiments with the small model No. 2, composed of an upright spindle having a piece of brass wire 12 inches long, weighing 4 ounces, put through the top part of it, in such a manner as to allow of its being moved, and set longer at one end and shorter at the other, &c. The weight to give motion fell through a distance of 2 feet 4 inches in each experiment.

Table of Experiments.

No. of Experiment.	Particulars of Experiment.	Weight to give Motion.	Time in Motion.	No. of Revolutions.
		Lbs.	Seconds.	No.
1	The wire set in the spindle with the ends at equal lengths from the centre.	1½ 3 6	45 46 46	165 206 241
2	The wire set all out on one side of the spindle, and consequently out of balance.	1½ 3 6	32 33 30	56 56 57
3	The wire set 4 inches long at one end and 8 inches long at the other.	1½ 3 6	32 30 29	72 78 85
4	The wire with a 6 oz. weight upon one end, and set in the spindle in such a manner as to make each end of an equal weight.	1½ 3 6	56 56 59	143 173 206
5	The 6 oz. weight removed, the wire remaining in the same position as in the last experiment, No. 4.	1½ 3 6	36 33 29	67 70 69

The model No. 4 was made to more nearly resemble the railway carriage wheels and axle. It consists of a round axle fixed to run in two brass chairs, resting upon a small wood frame, with an eight-day clock spring and barrel upon the frame, to give motion to the axle, and by that means to keep its power within itself. There are two flanged wheels, one on each side of the axle, 6¼ inches in diameter, bearing about the same proportion as a railway carriage wheel; by placing some loose pieces of iron inside of the wheels so as to make them represent wheels that are ⅛ inch thicker on one side of the periphery than the other, and the thick sides on the opposite side of the centre (a position which it is the practice of wheel makers to place them in, and which, according to the models, is the very worst), if the string from the spring barrel is wrapped round the axle and let go, the model will begin to jump about the table; or if held in a person's hand, it will soon get the whole into a shake, so as to beat time with it in a similar manner to many of the railway carriages.

In the course of the reading of the paper, Mr. McConnell exhibited numerous experiments explanatory of the subject. The first showed the wheels of a model machine in balance, to which motion was communicated by a spring; and the regularity of the motion of the wheels was strikingly evinced. Afterwards a small piece of iron was inserted between the arms of each wheel at opposite points, which entirely destroyed the balance, and gave rise to considerable jerking or unsteadiness. Similar experiments were made to show the advantage of also balancing the piston rod, which more than anything else, Mr. McConnell believed, would obviate the unpleasant and sometimes dangerous jolting of railway trains.

With respect to the mode of balancing wheels, Mr. McConnell stated that two wheels could not properly be balanced together: first one is balanced, and then the other on the opposite side. When this subject was first brought under the notice of Mr. Robert Stephenson, it was not considered to have any value, and it had many opponents; but more recently Mr. Stephenson's attention and that of other eminent engineers had been called to it, and their opinion was now favourable. These parties however adopted another method, which he (Mr. McConnell) did not consider to be the correct one; namely, when a locomotive is to be connected, and the driving wheels and working parts to be attached, it is lifted upon centres and the wheels set slowly in motion, balance weights being added until they move at a particular speed without rocking, and become perfectly settled on their centres. That plan might answer tolerably well, but he did not consider it to be the really true method of balancing wheels. On a future occasion he would probably bring before the Institution the subject of balancing the piston and rod and connecting rod, to which he attached very great importance. He believed the want of this balance to have caused many such accidents as engines leaving the rails, even when the wheels were in balance; for when an engine attains a high velocity, say when the piston rod travels at the rate of 1000 feet per minute, the momentum of the piston becomes so great, that the engine must jump and oscillate, causing the front wheels frequently to clear the road. This effect he had succeeded in completely neutralising, in experimenting at Wolverton with an engine perfectly balanced. It was six years since Mr. Heaton introduced the

subject to him (Mr. McConnell), and he then adopted it on the Birmingham and Gloucester Railway. He believed that to have been amongst the first instances of its having been brought into practice.

Mr. Middleton said he knew that considerable prejudice had at one time existed against the system of balancing, so ably brought forward by Mr. McConnell. He had been associated with the author of the system, Mr. George Heaton, in having it tried on the London and Birmingham and other Railways, but they met with great discouragement. He was however still convinced that it was one of the best means of securing the utmost safety in railway travelling. It was first introduced in 1839, on the London and Birmingham line; and he had also then been in communication with Messrs. Sharp Roberts and Co., of Manchester, on the subject; but it was, as Mr. McConnell had stated, first adopted in practice on the Birmingham and Gloucester line.

Mr. McConnell observed that Messrs. Sharp Roberts and Co. did not take the true plan. Instead of balancing each wheel and each crank by itself, they put a balance weight opposite to the two cranks; and that system they carried on for a considerable time.

Mr. Cowper said that Messrs. Braithwaite and Milner had balanced wheels on the Eastern Counties lines eleven years ago; and after coming to Birmingham he had heard of Mr. Heaton's plan, which he found to be precisely the same as that on the Eastern Counties. This however was a decided improvement on any he had seen before.

On the motion of Mr. Henry Smith, seconded by Mr. Samuel Thornton, the unanimous thanks of the meeting were voted to Mr. McConnell for his valuable paper, and for the very complete experiments he had exhibited.

The Secretary then read the following Paper, by Mr. James Samuel, of London:—

B

ON AN EXPRESS LOCOMOTIVE ENGINE.

The small locomotive lately introduced on the Eastern Counties Railway having attracted considerable attention, has induced me to present to your notice a short description of it; and at the same time to offer a few observations on the applicability of the principle to the conveyance of passengers on branch lines of railway.

This "carriage engine" was constructed, under my superintendence, for the purpose of conveying the inspectors and myself on the Eastern Counties Railway, and thereby avoiding the great expense of special engines.

The total length of the carriage is 12 feet 6 inches, including machinery, water tank, and seats for 7 passengers; all on one frame, which is hung below the axles, and is carried on four wheels 3 feet 4 inches in diameter. The floor is within 9 inches of the level of the rails. It is propelled by two cylinders, 3½ inches in diameter, with a 6 inch stroke, placed on each side of the boiler, and acting on a crank axle. The boiler is cylindrical, placed vertically; and is 1 foot 7 inches in diameter, by 4 feet 3 inches in height. It contains a firebox, 16 inches in diameter, by 14 inches in height; with 35 tubes, 3 feet 3 inches long, by 1½ inches in diameter; giving 5½ feet of heating surface on the firebox, and 38 feet on the tubes. The engine is fitted complete with link motion, feed pumps, &c. The water tank is placed under the seats, and will contain 40 gallons.

This carriage is capable of conveying 7 persons, at a rate of 30 miles an hour; it has at times attained a speed of 44 miles. The consumption of coke is only 2½ lbs. per mile; and the weight of the whole machine does not exceed 25½ cwt., including coke and water.

The result of observations which I have for a considerable time been making on the Branch *Passenger* Traffic of Railways has been to convince me that, on the whole, it is not remunerative; and in some cases it is even worked at a loss. I have therefore been led to consider, whether the expenses might not be reduced by the introduction of a system of steam carriages more suitable to the amount of traffic to be conveyed.

It is evident that the more we can reduce the dead weight of the trains and engines, in proportion to the number of the passengers, the less will be the expense of repairs, both of the carrying stock and engines, and of the way and works of the line.

The average weight of a train on the branch lines of the leading railways is 56 tons, the number of passengers conveyed by each train not exceeding 35 to 40 on many of the branch railways in England. Supposing each passenger with luggage to weigh 1½ cwt., the total weight of the passengers conveyed is about 3 tons; or in other words, for every ton of paying load now carried by the system of locomotion, we have 18 to 20 tons of dead weight.

It is therefore in a commercial point of view of the greatest importance, not only to railway companies but also to the public generally, that some less expensive and at the same time equally safe means of transit be adopted.

Accordingly it is proposed to substitute for locomotives, on branch railways, steam carriages similar in construction to the accompanying drawings.

These drawings represent a patent steam carriage now in course of construction, under my direction, by Mr. W. B. Adams, the patentee; intended for the Eastern Counties railway company.

The following are a few of the principal dimensions:—diameter of cylinders, 7 inches; length of stroke, 12 inches; diameter of driving wheels, 5 feet; distance between centres, 20 feet; width of framing, 8 feet 6 inches. The boiler is of the ordinary locomotive construction, 5 feet long by 2 feet 6 inches in diameter; the firebox is 2 feet 10½ inches by 2 feet 6 inches. There are to be 115 tubes 1½ inches in diameter and 5 feet 3 inches in length; giving 210 feet of heating surface on the tubes. The area of the firebox is 25 square feet; giving a total of 235 feet of heating surface on the boiler.

The consumption of coke I have estimated at 7 lbs. per mile at a velocity of 40 miles per hour. The total weight of the steam carriage, with coke and water, will not exceed 10 tons; and it will be capable of conveying about 42 passengers, at a speed of 40 miles per hour. The water will be carried below the floor of the carriage, in wrought iron tubes 12 inches in diameter and 12 feet long.

One great object attained in this machine is the reduction of the centre of gravity; from which there will be a consequent absence of lateral oscillation. It is intended for the Enfield and Edmonton branch of the Eastern Counties railway, and is expected to be at work in about 3 months from this date. When its practical utility and economy have been proved, I shall be glad to submit the results to the Institution; as I feel convinced that the subject is one deserving the attention of the members, and of all parties interested in the profitable working of railways.

I may add that were the system of light steam carriages adopted, branch railways might be constructed at a very small cost indeed, compared with the present outlay; an outlay which is unavoidable with the system of heavy engines; and the advantages of railway accommodation might be extended to districts which can never hope to enjoy them so long as the present system, which requires so great an outlay of capital, is continued.

Mr. Samuel begged to state that one of the chief recommendations of his engine was the very great saving it would effect in the wear and tear of rails, arising from the difference in weight between it and the present class of engines. From experience he estimated the wear and tear of rails at £80 per mile per annum; besides the wear in the tyres of the driving wheels, which all know to be large. In constructing branch lines, and also where the traffic was light, he proposed to lay light rails and to use only these little engines; and by these means, the first cost of such lines, as well as the current expense, would be very materially lessened.

In answer to questions by Mr. Cowper, Mr. Samuel said that there would be no difficulty in providing for the conveyance of goods or passenger trains more than usually heavy; and in answer to the Chairman he said that it would be desirable to lay the light rails he had spoken of on longitudinal timbers, so that heavy engines might, as occasion required, run over them with safety.

A Member enquired what amount of steam pressure the engine usually worked with.

Mr. Samuel replied that the usual amount was 120 lbs.; but it was not his intention to work with more than 80 lbs. in future.

The Chairman and Mr. Cowper concurred in thinking that for branch lines, where the traffic is not usually heavy, Mr. Samuel's engines might be used with considerable advantage and economy, and that by some such means these lines, generally so unproductive, might be made remunerative to the proprietors. The Chairman however thought an objection might be taken that the passengers would be subject to a delay at the junction with main lines.

Mr. Samuel replied that the delay would be amply compensated for by the increased speed he expected to obtain. He might add that he had made a calculation that the cost of conveyance of passengers by his arrangement would not exceed one fifth of a penny per mile. All would admit that the unprofitable working of most branch lines demanded that some means of economising the expenses should be introduced.

The Chairman did not think it advisable to lay down lighter rails than those now in use. In conclusion he begged to intimate that the engine in question was at the London and North Western Birmingham station, in steam, that the members might personally witness her working.

Mr. Buckle then proposed that the best thanks of the Institution be given to Mr. Samuel; the motion was seconded by Mr. Cowper, and passed unanimously.

Mr. Thomas Craddock, of Birmingham, having expressed a desire to lay before the Institution a supplementary paper to the one read by him at the last meeting, read the following Paper :—

ON A BOILER AND CONDENSER SUITABLE FOR EXTENDING THE CORNISH ECONOMY AND FOR PREVENTING BOILER EXPLOSIONS.

At the last meeting of the Institution several questions were put to me, some of which I was not at the moment prepared to answer. The question put by Mr. McConnell relative to the economy of my boiler in the generation of steam, when compared with the common boiler, I am not even yet prepared to answer; as I have not been able to find time to make such experiments with the two boilers as would enable me to make a conclusive reply. Before referring to other questions raised at that meeting, I will offer a few observations on the advantages of two cylinders when used for expanding steam from a very high to a very low pressure, as proposed by me. Mr. Crampton alluded to the loss shown by the curve of the indicator figure, and I am quite as sensible of this loss as Mr. Crampton or any one else can be; as long ago I publicly assigned that as the reason which had induced me to design and construct engines on the principles of the one now before this meeting, which on investigation will, I think, be found calculated to effect the object desired. But I wish to remind the meeting, that the indicator will not detect the loss alluded to as that arising from the steam being condensed by the comparatively cold metal of the cylinder; the water resulting from such condensed steam being in contact with the heated metal, and having free communication with the condenser, re-absorbs the heat, thus rendering that heat and water inert when we require it active, and active when we require it condensed. I think however that the validity of Mr. Crampton's assertion is open to question. He asserts that the flywheel will meet the objections without the two-cylinder engine. If the irregularities and other difficulties attending the one-cylinder system are not considerable, the flywheel will meet the difficulty; but the matter is very different when, as in my case, we avail ourselves of the expansive principle to the fullest extent; and to render that safe and practicable was the primary motive which led to these arrangements. To illustrate the matter, let us suppose it desirable to use steam at the commencement of the stroke at 200 lbs. per square inch; that steam

being reduced by expansion before it quits the cylinder to 3 lbs. per square inch, which would require the steam to be cut off at about $\frac{1}{64}$th of the stroke, to do which in one cylinder it must be of large capacity; hence we have 200 lbs. per square inch acting upon an extensive piston area at the commencement of the stroke, and at its termination only 3 lbs. It must be very obvious that this would produce immense strain upon all the working parts of the engine; to meet which they would require to be inconveniently heavy and strong; besides, what weight of flywheel would be required to equalise such a motion? Yet, with an engine on similar principles to the one before the meeting, all the difficulties are met by a reduction of weight and bulk of engine. The strain also upon the various working parts is kept quite as low as in the low pressure engine. I think if gentlemen will bear in mind these reasons, and others which will readily suggest themselves, they will agree with me that there are strong and valid grounds for concluding that the double cylinder engine does possess advantages for carrying out the expansive principle as I propose it; advantages which are supported by the soundest theory, and are confirmed by practice.

In replying to other questions, I shall endeavour to be brief. In large boilers, such as those exhibited in the drawings before the meeting, for marine and locomotive purposes, the extent of surface on which the heat generated in the furnace acts is 30 square feet for every 62 lbs. of steam required to be generated per hour; three fourths of such surface being exposed to the radiant heat and one fourth to the communicative heat. The extent of surface required in the condenser to condense 62 lbs. of steam per hour is 70 square feet when air is the medium of condensation. With water as the medium of condensation, 16 square feet of surface is sufficient for the condensation of 62 lbs. of steam per hour. With air as the medium of condensation, 62 lbs. of steam, generated under a pressure of 100 lbs., will with such engines produce at least 3 horse power. And with water as the medium of condensation, 4 horse power is easily obtainable from 62 lbs. of steam per hour. From this it follows, that the surface necessary in the condenser per horse power is one third of 70 square feet, or $23\frac{1}{3}$ feet; whereas with water as the medium of condensation, the surface required in the condenser will be one fourth of 16, or 4 square feet per horse power.

In reference to weight of boiler, condenser, and engine, I am prepared to state that the boiler, with casing, grate, steam chest, and all complete, does not exceed 1 cwt. per horse power. The condenser, when air is the medium of condensation, does not exceed $\frac{3}{4}$ cwt. per horse power; and with water as the medium of condensation, the condenser would not exceed 40 lbs. per horse power. The coal required, with air as the medium of condensation, is 3 lbs. per horse power per hour; and with water as the medium of condensation, it would be even less than 3 lbs. Again: we find the weight of boiler, condenser, and engine, even with air as the medium of condensation, not to exceed $2\frac{1}{4}$ cwt. per horse power. If we contrast this weight with that of the "Banshee" engines, lately tried in a government vessel, which is a fair weight of the present make of engines, we find the "Banshee" engine and boilers with water weigh 280 tons for 350 horse power. The weight of an engine, boiler, and condenser, on the principle of the one before the meeting, equal to 350 horse power, would not exceed 60 tons; which is not one fourth of those of the "Banshee": whilst I know that the consumption of fuel would be reduced nearer two thirds than one half of that necessary in the instance given.

Much was said at the last meeting about a comparison in actual work. Since then I have been informed by Mr. Humphries of Pershore, that with one of these engines, made for him by me, and which is far from being so perfect as experience would now enable me to make it, he thrashed 50 bags of "gardy" cut wheat with 3 cwt. of coals; whilst a neighbour of his with another engine thrashed 30 bags of wheat with 30 cwt. of the same quality of coal.

Mr. Craddock added that these boilers would, if necessary, generate steam at 200 lbs. pressure; and yet no such accident as that which had recently occurred at Dudley could take place. In answer to a member, he stated that he had been in communication with the Admiralty, who said they could not adopt his suggestion. He did not know what their opinion was, but his were not suggestions, they were facts; and he had an engine of nearly 100 horse power constructed on this principle.

Mr. Henry Smith wished to know the comparative power of working the refrigerator and the common pump.

Mr. Craddock replied that a condenser equal to 40 horse power would not take one horse power to drive it. It had been objected that the joints of the refrigerator were not tight; but he would engage to construct them perfectly so.

Mr. McConnell enquired how the water in the boiler was kept at a regular height.

Mr. Craddock replied that there were taps for the purpose.

Mr. McConnell said he had previously asked the question of the relative economy of this engine and the one somewhat similar to it in power at the London Works, and he did expect that either Mr. Craddock or Mr. Cowper would ere this have given the Institution some data to found an opinion upon.

Mr. Craddock said he had stated the relative economy to be 50 per cent., and it rested with Mr. Henderson and not with him to explain why the trial had not been made. He (Mr. Craddock) had always been anxious for it.

Mr. McConnell could not doubt the statement of Mr. Craddock, and he was anxious to give the engine every proper advantage; but when that gentleman talked of saving 50 per cent., it became an important matter to have some data by which to arrive at an opinion; and he thought the Institution should not be committed to anything which had not been accurately and sufficiently tested by experiment.

Mr. Cowper said 50 per cent. might seem rather large; but they knew that the Cornish engine effected a saving of nearly 60 per cent. over the old engines.

Mr. McConnell said his only wish was to prevent the Institution committing itself to an opinion, without having the merits of the engine fairly tested; but he would be quite willing to admit its superiority, whenever he had the proper data upon which to decide. The question of the relative advantages of the double and single cylinders was not yet settled, and one of the members had been requested at the last meeting to prepare a paper on the subject. He thought therefore that experiments should be made, in order to determine the relative economy of the two engines. It had been suggested to him, as the Chairman of the meeting, that a committee of members might be appointed

to make the necessary experiments with Mr. Craddock. If that would be satisfactory to Mr. Craddock, he believed that it would be satisfactory to the members of the Institution.

To this arrangement Mr. Craddock willingly assented; and the Chairman announced that the Council would name the committee whenever Mr. Craddock intimated that he was prepared to carry out the experiments.

The Secretary then read the following Paper, by Mr. William Smith, of Dudley:—

ON THE RECENT BOILER EXPLOSION AT DUDLEY.

Having collected numerous particulars connected with the lamentable explosion of a steam boiler at the works of Mr. Jeffries, Hart's Hill, near Dudley, which occurred on the morning of Friday the 2nd inst., I have great pleasure in laying them before the Institution; and for the better elucidation of my statements, I have prepared a drawing of the section of the boiler, and of a puddling furnace which was one of four, the heat from which acted upon the boiler.

The boiler here alluded to is in this district termed "an egg-shaped furnace boiler," from being heated by puddling furnaces. The sectional sketch which I now produce will show the form, and also the distance and position in which it stood to the furnaces, one of which acted upon each quarter of it, at right angles; the flame from the neck of the furnaces coming first in contact with the lower part of the outside shell, and then ascending to the cross flues, passed through them, and descended through the vertical flue to the chimney.

I shall now state the dimensions of the principal parts; together with the calculations of heating surface, steam space, &c.

The boiler being, as before stated, egg-shaped, or rather a plain cylindrical one with hemispherical ends, there were four cross flues, and one main flue in the centre was placed in a vertical position, as shown

in the drawing. Its extreme height was 19 feet, and 9 feet 3 inches in diameter ; the diameter of the four cross flues was 1 foot 10 inches, connecting the shell to the top part of the main flue, which was 5 feet in diameter at top, and 3 feet 9 inches at the bottom ; the height from the bottom of the boiler being 14 feet.

The heating surface would therefore be :—

Outside shell	160	square feet.
Four cross flues	50	„
Main flue	196	„
Total ...	406	square feet.

Allowing 12 inches of water above the main flue would give 668 cubic feet contained in the boiler : the remaining space for steam would be only 169 cubic feet. In order to form an opinion as to the quantity of water evaporated per hour, the quantity of coal consumed in the furnaces must first be ascertained. It was as follows :—each furnace puddled between 22 and 23 cwt. of iron in 12 hours, and consumed between 28 and 30 cwt. of coal in six charges; and the operation is performed by first raising the furnaces to a white heat, until the charge of iron is melted, which takes about half an hour; after which the damper is shut nearly close until the puddling process is finished, which takes about 40 minutes; and the blooms are drawn out and the furnace reheated for another charge. We have then 29 cwt. of coal consumed by each furnace in 12 hours, and $\frac{29 \times 112 \times 4}{12} = 1083$ lbs. per hour; and supposing, under the circumstances, that 20 lbs. of coal would evaporate 1 cubic foot of water, we have 54 cubic feet per hour, which I think is nearly correct. The result then for comparison is :—

Heating surface	406	square feet.
Steam space	169	cubic feet.
Water space	668	cubic feet.
Water evaporated per hour	54	cubic feet.
Coals consumed per hour	1083	lbs.
Coals consumed for one cubic foot of water evaporated	20	lbs.
Diameter of steam pipe to engine	5½	inches.
Diameter of safety valve (one)	4	inches.
Diameter of feed pipe...	2¼	inches.
Thickness of all the plates of boiler...	$\frac{7}{16}$	inch.
Pressure per square inch on the safety valve (supposed)	45	lbs.

The above facts show that the steam space in this boiler was much too small for the heating surface and for the other proportions of the boiler; and having examined the boiler on the 28th of April, I was aware of that fact, and advised Mr. Jeffries to make an addition to the steam space, as shown in my drawing by red lines. This boiler worked in connexion with another cylindrical boiler about 25 feet long and 5 feet 6 inches in diameter; of the ordinary construction, and heated in the ordinary way. Both together supplied steam for a cylinder 20½ inches in diameter and 6 feet 6 inches stroke, making 20 to 22 strokes per minute. About four o'clock on the morning of the accident this latter boiler was shut off, from being found to be leaking, and the boiler which exploded was left to work the engine by itself. This it did for about 2½ hours, and then exploded. It appeared in evidence that the engine was doing very little work at the time of explosion, as it was driving only the gearing and a roll turning lathe at which the proprietor himself was working; but all the four puddling furnaces were in full work, and a great quantity of steam must have been blowing off by the safety valve, and the engine acting on the very small steam space had, in all probability, caused the boiler to prime, and suddenly thrown out a large portion of the water. I examined the pieces of the boiler about four hours after the explosion. The boiler was torn up in all directions; and I am convinced, from the appearance of the plates, that it had been short of water, and that the top part of the main flue, and the cross flues, had been red hot. I am also of opinion that the main flue had either collapsed in the first instance, or otherwise the crown of it had been forced downwards, and the steam or water descending into the main flue to the chimney had blown it up, as also the stack which stood at about six yards from the boiler. Other particulars will be seen in the evidence given at the inquest; but I am sorry to say that the real cause of the accident seems still to be a mystery; it not being possible to ascertain the exact amount of weight upon the safety valve at the time, from the great difference of statement made by the two enginemen, and the proprietor appearing to be perfectly ignorant of it himself.

The CHAIRMAN enquired if Mr. Smith could assign any cause for the explosion.

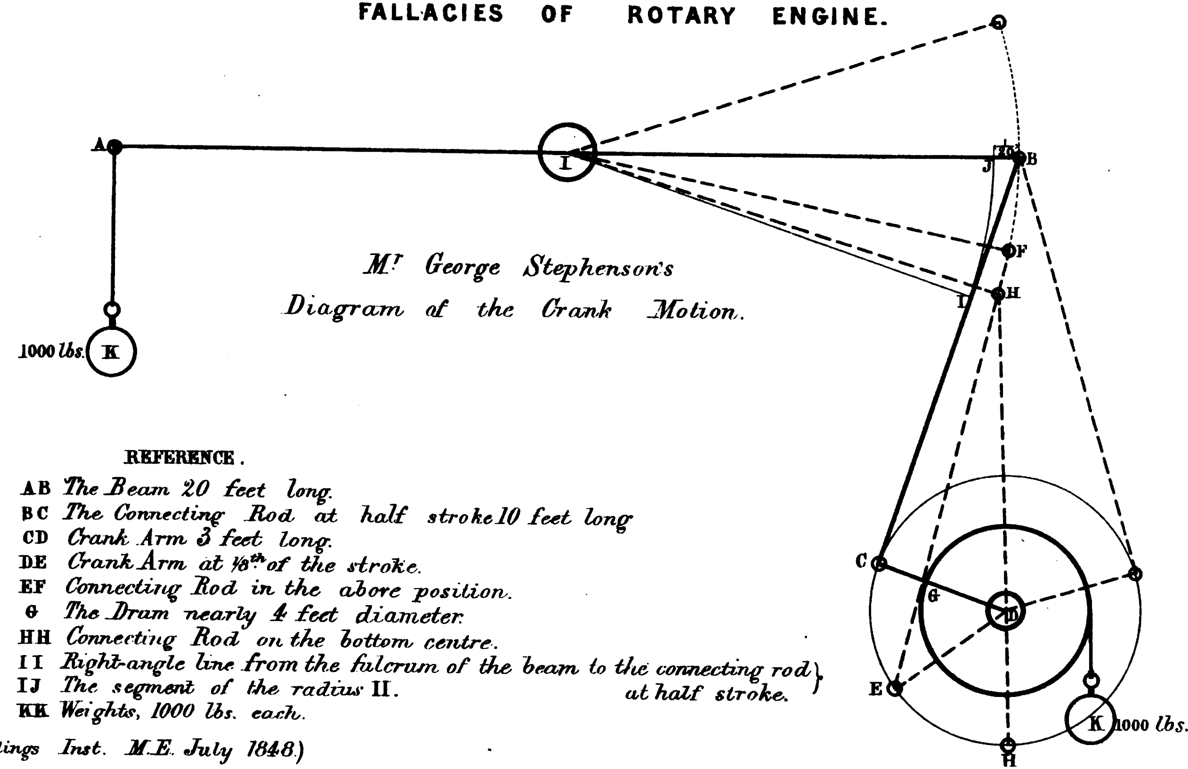
Mr. SMITH was convinced that the water in the boiler had become too quickly heated; which no doubt was one of the principal causes.

Mr. COWPER enquired if there were any stays to the flues.

Mr. SMITH said there were not, although the engine was working at 45 lbs. pressure. He was of opinion that the boiler was not at all adapted to work high pressure steam; it was on too large a scale, and there are many such in the neighbourhood of Dudley, but used chiefly for condensing engines. As near as he could ascertain, the boiler in question had been working at about 45 lbs. to the inch; which is quite a general thing in the neighbourhood. In fact many engines are being daily worked there in a highly dangerous manner, and he felt strongly that, for the safety of the public, some general superintendence should be established. It was most unsafe to allow matters to continue as at present.

A vote of thanks to Mr. Smith was unanimously passed, and the meeting terminated.

FALLACIES OF ROTARY ENGINE.



Mr. George Stephenson's
Diagram of the Crank Motion.

REFERENCE.

AB The Beam 20 feet long.
BC The Connecting Rod at half stroke 10 feet long
CD Crank Arm 3 feet long.
DE Crank Arm at 1/8th of the stroke.
EF Connecting Rod in the above position.
G The Drum nearly 4 feet diameter.
HH Connecting Rod on the bottom centre.
II Right-angle line from the fulcrum of the beam to the connecting rod at half stroke.
IJ The segment of the radius II.
KK Weights, 1000 lbs. each.

(Proceedings Inst. M.E. July 1848.)

PROCEEDINGS.

26 July, 1848.

The usual General Meeting of the Members was held in the Theatre of the Philosophical Institution, Cannon Street, Birmingham, on Wednesday, the 26th of July, 1848; George Stephenson, Esq., President, took the Chair at four P. M.

The Minutes of the previous Meeting were read by the Secretary, Mr. Kintrea, and confirmed.

The President said that the first paper to be read according to the programme would be his own, "On the Fallacies of the Rotary Engine;" and having alluded to the model of a rotary engine before the meeting, by Mr. Onion then present, he invited the fullest discussion on his paper and on that model. He would show that no power was either gained or lost by the crank; and that in effect it was precisely the same as a simple lever. He then exhibited a diagram explanatory of his views; and read the following Paper:—

ON THE FALLACIES OF THE ROTARY ENGINE.

As all levers give out their powers at right angles to their fulcrums, it will be seen that the right-angle line I I (referring to the accompanying diagram), from the connecting rod to the centre of the beam, will be the true measure of the length of the beam, when the crank is at half stroke; therefore 1-20th of half the length of the beam will be gained by the piston end of the beam. The crank being 3 feet long, the up and down stroke of the piston will be 12 feet; the crank pin will of course have passed through a space of nearly 19 feet.

Now a weight hanging upon the drum, which is nearly 4 feet in diameter, will balance the same weight on the piston end of the beam; each will move at the same velocity, and pass through the same space in the same time.

It will be observed that from C to D is a little more than one third longer than from G to D; it will therefore be seen that the weight at the piston end of the beam has a little more than one third advantage over the weight at the drum. And it will also be seen that from C to E is half way from half stroke to the bottom centre; at this portion of the stroke the leverage of the crank will be nearly 2 feet. The increased power that existed in the crank from half stroke to this point will gradually be lost from E to H: it is therefore clearly proved that no power is lost by the crank motion, as the weights resolve themselves into a simple lever. There will be a little loss of power when the engine is turning the centres, which is compensated for at the connecting-rod end of the beam by the segment of the right-angle line I I.

Now a rotary engine can only give out its power on the arm, like any other lever; and if the piston passes through a space of 19 feet, it will just balance a weight equal to the same power passing through the same space.

The President went on to observe that the fallacy of Mr. Onion's principle was pretty conclusively proved by the fact that fifty patents at least had been taken out for rotary engines, every one of which had failed. No man who ever lived could improve on the lever principle, as there was no power but in the lever. He would now be glad to hear the opinions of the members, and also any explanation that Mr. Onion might wish to offer.

Mr. Onion then stated that his engine had been working for some weeks at the Derby station by permission of Mr. Kirtley, the locomotive superintendent of the Midland Railway; and during that trial experiments with his and another engine had proved that his

effected a material saving in fuel. A statement to that effect, authenticated by Mr. Kirtley, was now in the possession of Mr. McConnell, at whose suggestion he attended that meeting.

The PRESIDENT said that it appeared to him to be impossible that such could be the case. The engine might have answered at one trial, but it might fail at the next; and one trial was by no means a sufficient proof.

Mr. SLATE observed that there was one important desideratum which he desired to see obtained in the rotary engine, namely some method of packing tightly. That had never yet been found. He had paid much attention to the rotary engine, and had seen approaches made to an efficient system of packing, but none had been so perfect as to render the rotary principle equal to the crank. Mr. Onion had told them that his engine was more simply packed than the common engine, and he should like to have that made quite clear to the meeting.

Mr. ONION said that Mr. Scott Russell, who had written on and patented several rotary engines, confessed to him that he (Mr. Onion) had succeeded in overcoming difficulties which had hitherto been found to be insurmountable; such as making his engine steam-tight, and also doing away with the usual noise of the rotary engine. He was satisfied that his engine would bear a comparison with one upon any other principle.

Mr. JOSEPH MILLER said that one great advantage of the rotary engine, supposing it to be thoroughly efficient, was the small space which it occupied. If it were made as perfectly tight as the ordinary engine, admitting that tightness was one of the advantages of the common crank, a useful result would be accomplished. He had never yet seen a rotary engine rendered sufficiently tight, but he would not go the length of saying that it could not be done. As a practical man however he saw great difficulties in the way. He had never seen a rotary engine which remained tight for any length of time; and he should as soon expect to discover the perpetual motion as to make one which would.

The PRESIDENT observed that if he believed there was anything in Mr. Onion's engine he would be very happy to give his assistance

in bringing it before the public; but he really could not see anything of value in it.

Mr. Miller thought that the question of the crank and the rotary engine ought now to be finally settled. It was very desirable that that should be done.

Mr. Henry Robinson, on being referred to, said that the Government had a rotary engine (Lord Dundonald's) working in the Portsmouth dockyard for the last seven years. Mr. Onion claimed the credit of being the first who had ever succeeded in packing efficiently; but it was only the same packing as he (Mr. Robinson) had been in the habit of using for years; Mr. Onion had not therefore advanced anything at all new. If Mr. Onion would call upon him in London, he would show him an engine similar to his own, and packed in the very same way. It was one that was applied to a locomotive, and commonly known as the "Jim Crow" engine, from its having been painted black. The difficulty with rotary engines had hitherto been in keeping them tight. The difference between Mr. Onion's engine and the one at Portsmouth dockyard was that in the latter the packing did not depend upon springs. All that he (Mr. Robinson) was prepared to say about that engine (Lord Dundonald's) was that it had hitherto done the work which it was intended to do.

The President asked if any member was of opinion that there was a loss of power by the use of the crank. They had heard his reasons for asserting that there was no loss; and he wished that those who entertained a contrary opinion should declare it.

A Member having spoken of Beale's rotary engine, the President stated that he had been concerned in having a trial made of that engine in a steamboat intended to carry passengers a short distance of only half a mile, to Yarmouth; but when the engine was put to work he could not get the boat to move forward, and so the experiment failed. He managed to get the boat to sea, and it cost him and his party £40 to bring her back again. As to Lord Dundonald's engine, he was invited on one occasion to see it tried on the Liverpool and Manchester Railway; but he refused to go, because he was convinced that a failure would be the result; and so

it was, for the engine could not be made to draw a train of empty carriages.

Mr. Robinson :—But I think you will agree with me that there is no loss of power consequent upon the principle of the rotary engine.

The President :—Not if you make it tight.

Mr. Robinson :—The object of the rotary engine is to economise space and power; and if we cannot attain that end, there is something wrong in the mechanical means which are made use of.

Mr. Benjamin Gibbons said that the only difficulty with the rotary engine was to keep it tight; but after trying many experiments to overcome that objection he had never succeeded.

The President then called on Mr. William Buckle, who read the following Paper; having first premised that he had chosen the subject in order to give variety to the proceedings.

ON A MACHINE FOR PREPARING BONE MANURE, &c.

The object of this communication is to endeavour to direct the attention of agriculturists to the usefulness of a machine for preparing Bone Dust, which has been found to be a most valuable manure. The machine is alike available to improve the nobleman's estate or the peasant's cottage garden. An ash plant, an iron bar, a pebble from the brook, and a hand sieve, furnish a bone mill for all that a peasant requires. The arrangement of this machine reduces bones to a state of meal, and thereby prepares them for a rapid change into a state of solubility; the rapidity of the effects of phosphate of lime on the growth of plants depending upon its greater or less solubility. In all other mills I have examined, their construction merely provides for crushing the bones into lumps,

which when laid on the land in that state remain many years undecomposed, producing meanwhile little benefit to the crops.

In the year 1833 my attention was directed to this subject, the steward of a large estate in Oxfordshire having requested me to construct a mill to grind bones as fine as could possibly be done; as he found in practice that the bones prepared in the usual manner were of little benefit. He also objected to the usual method of boiling the bones before they were crushed by the rollers. I accordingly constructed a mill, which was driven by two horses, and which succeeded so well that I was requested to increase its power and to work it by a water wheel of three horse power. The first crop of turnips averaged for each turnip 47 inches in circumference and 32½ lbs. in weight, produced from seed of the red round turnip, received from Messrs. Drummond and Son of the Agricultural Museum in Stirling. They were sown in May, and produced as above in October.

In the year 1839 I constructed a bone mill, which was erected on an estate in Surrey. It was driven by a water wheel, 13 feet in diameter and 4 feet wide; with additional conveniences to the first one. After a careful course of experiments had been gone through, I received a letter from the proprietor of the estate, of which the following is an extract:—"I am much obliged by all the attention you have given to my bone mill, with the performance of which I am entirely satisfied; and I hope something may bring you towards London, that I may have an opportunity of showing you how complete a work of the kind I have; indeed I know of nothing to compete with it for such a purpose; and the manner of letting the water on to the wheel renders the whole so safe and secure, that I have yet to learn how we could do better. Melville (the millwright who has erected the mill) has prepared himself with experiments in all ways, so as to answer such enquiries as you may make; and being thus fortified, I will not trouble you with any detail, but merely state that we produce 13 bushels of fine dust per hour, and that 17 bushels of fine dust appears to be the product of ½ ton of raw bones. Thus we shall be able to produce 136 bushels of dust from 4 tons of raw bones per day of ten hours."

In the mill or machine represented in the drawing before the meeting I have introduced several additions and improvements, which were not in the former ones. The position of the stampers is altered, as dictated by experience; and the elevators are an addition of much usefulness, as by them are lessened the duties of the attendant, whose only care is to admit water on to the wheel, to observe that the store of rough raw bones is ample, and that generally the machine is working satisfactorily. The rough bones are recommended to be heaped together in a shed adjoining the mill, from whence they should be made to slide down an inclined platform into the stamper trough. The middle stamper is recommended to be heavier than the outside ones, to enable it to break the large bones in pieces; those pieces pass on in the trough, from one stamper to another; and by the time they have reached the outside stamper, they are reduced into meal. The meal then passes into the dressing cylinders, which are placed on a descent, and by their velocities force the fine dust or meal through the wires; the coarse dust falls from the end of the cylinders into a box, from which it is raised by the elevators, and descends into the stamper trough, to be crushed fine enough to pass through the wire meshes of the dressing machine. I also recommend the application of elevators for conducting the ground bone dust from the bins or store in the cellar into the wagons, to be by them conveyed to the drill or sowing machinery.

The usual practice of those farmers in Oxfordshire who use this bone mill is to pare as much old turf as they can from the sides of the roads, under the hedges, and other places where they can find it, which when dry is burnt to ashes. The ashes are then screened and mixed with bone dust, in the proportion of 8 to 10 bushels of bone dust with from 20 to 100 bushels of burnt ashes, according to the condition of the land they are working. This mixture is put into the front hopper of a drilling machine constructed as an appendage to the bone mill, and the seed into the second or break hopper; they are by this means both sown at the same time, the raker or harrow and the brushes at the after part of the machine following and finishing up the work to be done. Should the season

prove favourable, the crop will be abundant. An intelligent and practical farmer informs me that 12 bushels of bone dust, each 66 lbs., were considered a good dressing for an acre of land, and equal if not superior to 12 tons weight of stable or farmyard manure; that the finer the bone dust is prepared, the sooner it will be changed into a liquid state, and only in that state would it, or any other manure, benefit the land; and that bones prepared in the usual way remained unchanged in the land, with little benefit to the crops.

As intimately connected with the subject of my paper, I may perhaps be allowed to allude to the surprising improvements which steam power has effected in agricultural science. To Professor Liebig of Giessen, the leviathan in chemistry of the present century, is the world greatly indebted for his deep and valuable researches in art and agriculture. He shows satisfactorily that agriculture is both a science and an art. The knowledge of all the conditions of the life of vegetables, the origin of their elements, and the sources of their nourishment, form its scientific basis. From this knowledge we derive certain rules for the exercise of the art: the principles upon which the mechanical operations depend, the usefulness and necessity of these for preparing the soil to support the growth of plants and for removing every obnoxious influence. No experience drawn from the exercise of the art can be opposed to true scientific principles; because the latter should include all the results of practical operations, and are in some instances solely derived from them. Theory must correspond with experience, because it is nothing more than the reduction of a series of phenomena to their last causes.

The vast improvements which have taken place in Cambridgeshire and the Bedford Level may be traced to three primary causes:—firstly, the improvement in the rivers which pass through the Level, consisting in strengthening their banks, deepening their beds, and particularly improving their outlets to the sea; secondly, the substitution of steam engines for draining, in lieu of the old wind mills; thirdly, the introduction of "claying," now universally practised

through the Level, where the clay can be obtained. On each of these heads I shall take leave to make a few brief remarks.

The several rivers which traverse this Level, from the uplands to the German Ocean, are confined to their channels by banks or mounds on each side, varying in height according to the elevation or depression of the land they are intended to protect. In times of heavy rain, when a large quantity of water comes from the high lands, those banks are often filled almost to their summit, and the stream flows between them at a height of 10 or 12 feet above the surface of the surrounding country. Originally those banks were formed entirely of such soil or earth as was obtainable in their immediate vicinity, consisting mostly of silt or peat, too porous and too light to resist the pressure of the flood; hence they frequently gave way and destructive inundations were the consequence. They are now much strengthened and improved by repairing them with better materials, chiefly gault, carried in boats at much expense and labour. Many miles of them are secured from leakage by having a wall of puddled gault sunk 7 or 8 feet deep along the centre.

At the commencement of this century, the outfalls of those rivers to the sea were in such an obstructed state, from the loose shifting sands brought into them by the tides, and particularly from the wide flat and circuitous channels through which they had to flow, that it was impossible in times of heavy rain in the uplands to discharge the floods which had to traverse the Level to the sea; hence broken banks and inundated districts were of frequent and ruinous occurrence. To remedy these evils, a cut or drain at the lower end of the Ouse near Lynn, called the Eau Brink Cut, after having been in contemplation for centuries and largely encountering the common lot of all great improvements from the hostility of ignorance and prejudice, was opened I think in 1818. By narrowing the channel, shortening the course of the river nearly five miles, and avoiding the loose shifting sands which choked the old outfall, this cut or drain has proved of immense benefit to the middle and south parts of the Bedford Level. In short no serious cases of broken banks or inundation have happened since its completion. Great improvements have also been made in the beds of those rivers by

means of the steam dredging engine; which, by removing hard substances, by deepening shallow parts, and by removing other obstructions, so as greatly to increase the scouring effect of the current, has tended very much to the efficient draining and preserving of the Level.

The application of the steam engine to drainage purposes was the second great step in the improvement of the Bedford Level. Under the old system of drainage by means of wind mills, it frequently happened that, after a great fall of rain accompanied by high wind, a dead calm of several weeks' continuance would succeed; during which time the mills were entirely useless, and the water often overflowed the land in the interval, destroying the crop, and rendering its cultivation, particularly with winter grain, a very precarious and often a ruinous venture. But, thanks to the conceptions of James Watt and the creations of Soho, our fen farmers can now commit the autumnal seed to the ground with as much confidence as their neighbours of the surrounding hills; and can hear the rains rattle against their chamber windows, through the long winter night, undisturbed by a dream of seeing their wheat lands under water in the morning, a dream which often broke the rest of their fathers and awoke them to witness its ruinous realities. The wreaths of smoke issuing from the tall chimneys of the fen-man's steam engines, like the rainbow to Noah, are hailed by them as a pledge and promise that the waters shall no more become a flood to destroy the fruits of their labours and blast their harvest hopes.

The third and crowning step in the scale of improvement was the introduction of the process of "claying," which took place about twenty years ago. It must be understood that the original surface of the land, from some unknown convulsion of nature or geological disruption, is at present very different from what it formerly was; as the evidences of its having once been high and dry land abundantly testify, in the sylvan remains so frequently found, consisting of fine oak and other trees, the horns of deer, the teeth of wild boars, and bones and relics of other forest animals. Since this era it must have been overflowed by the sea, as it is

covered, in many places to the depth of several feet, with a marine sediment of silt or clay; the deposit exhibiting both those qualities in different places, with all their intermediate mixtures, from the finest warp of the colour and consistence of mercurial ointment for sheep, to silt as raw and quick as can be found on the sea shore at the present day; and all impregnated more or less with saline properties, indicative of their marine origin.

The present surface of the Level consists, to the depth of several feet, of a black peat or moor formed entirely of decomposed vegetable matter, which has accumulated during the course of a long succession of ages, from the abundant aquatic vegetation which grew up and rotted down, year after year, on the surface of the watery waste. This peat is mostly unmixed with the clay above mentioned, over which it forms a distinct superincumbent stratum. From all this it appears that the sea must have been excluded during the period of its formation. It must also have been partially dry at different eras of its history, as it abounds with the remains of soft-wooded trees, such as willow, alder, birch, &c., which all lie between the clay and the present surface, in all stages of decomposition. The peat stratum varies much in depth in different localities, from 2 feet or less to 12 feet or more; depending in a great measure on the drainage it has undergone since. Where the water is kept out of it by draining, it subsides and loses bulk very fast, rendering it necessary every few years to lower the dip of the water-wheels of the wind mills or steam engines employed in draining it.

It will readily be conceived that a soil so light and porous as this must necessarily, when drained sufficiently for cultivation, require some heavier mixture to render it more compact and adhesive than it naturally is; particularly when exposed by frequent ploughing to the evaporating action of the sun and wind. That desideratum is abundantly supplied in the rich bed of clay underlying it, in most instances at such a depth as to be practically available for this purpose. The process of "claying," as it is technically termed, is entirely manual, and may be briefly described as follows. The land intended to be clayed, after being properly cleaned and prepared, is measured out into parallel "stetches," from 12 to 16 yards wide, by

a ploughman, who draws a furrow where every clay "dyke" is intended to be. The "clayer" commences operations at one end of the furrow, and marks out an oval, about 3 feet by 6 feet; and from this space proceeds to dig out the peat, which he casts out *before* him, continuing to cast out spit after spit in depth, till he comes to the clay. The clay is thrown out on *each side*, in equal heaps, till each heap contains about a cubic yard in quantity: this is the process for the first hole. A space of 2 or 3 feet is left, and a second hole commenced, the peat out of this hole being thrown into the first, and the clay on each side as before, nothing but the clay being left on the surface. The peat out of each hole being cast into the preceding one, the heaps of clay are spread over the land in the same way as manure, and all the surface as equally covered as can be. The fertilising effect of claying on soils previously exhausted and almost worthless is astonishing; the produce being frequently from 5 to 6 quarters of wheat and 10 quarters of oats per acre. It is common to take two or three "white crops" in succession without any manure; and the land is permanently benefitted ever after. The general practice is to clay the land in winter or early in spring for oats; after which the land is sown with wheat in autumn. The land clayed in summer is mostly sown with cole-seed, and fed off or ploughed in autumn for wheat, which is not found to succeed so well on clay raised in autumn, as it is supposed to make the land too cold for the young plant in the succeeding winter, should the weather prove severe. The expense of claying ranges from £2 to £3 10*s.* per acre.

The introduction of claying has quite revolutionised the agriculture of the fens. The old course, before the adoption of steam drainage and other improvements for the security of winter crops, was to pare the surface in May or June, with a plough adapted to that purpose, having a broad share, kept very sharp by the frequent use of the file, to the depth of about 2 inches: after exposure to the sun for two or three days, the furrows or "flags" were cast up into heaps and burnt, the soil being of such a combustible nature when dry that it was soon reduced to ashes; and these ashes, when spread over the land, ploughed in, and sown

with colewort, produced grass on which to feed sheep in the following winter, the land being sown with oats in the following spring. A second crop of oats was sown the succeeding year, and the land "laid down" with rye grass for two or three years succeeding; when the same course of burning and cropping was repeated, without any other manure than the ashes and that left by the sheep which fed off the green crop. When it became practicable, by means of improvements in the drainage, &c., to raise wheat crops, the process was the same. This system was considered the *ne plus ultra* of fen farming for several years; but it proved a very exhausting process, as the repeated burnings destroyed too much of the staple of the soil: the diminished crops of the ashes became weaker at every repetition of the process; diminished crops of colewort gave less and less animal manure to the land: and the system was fast wearing itself out, when claying came to the poor fen-man's rescue, and a new era commenced in fen farming, which has completely superseded the old system, and introduced in its place what can be called no system at all, as there are now no regular courses or rotations of crops. The land is now almost universally under the plough; and when crop-sick with white corn, it is renovated with green crops of colewort, swede turnips, &c., drilled in with bones, rape cake, guano, &c.; but chiefly with bones, which are used to a great extent.

Mr. Cowper asked what was the shape of the stampers; they appeared to be in the form of a cross.

Mr. Buckle replied that the form was that of an inverted cross.

Mr. Cowper:—And the weight of the stampers?

Mr. Buckle:—The centre one is 4 cwts., the next 3 cwts., and the outside stampers $2\frac{3}{4}$ cwts. each.

Mr. Henry Robinson:—What is the height of the stroke of the stampers?

Mr. Buckle:—Sixteen inches.

Mr. Cowper :—At what speed do they go?

Mr. Buckle :—Forty blows per minute. The power is rather under three horse power; but the ordinary mills with rollers require from fifteen to twenty horses to do the same work. All know that a very heavily laden wagon might pass over a leg of mutton bone without having any effect upon it, while a smart stroke from a knife would be sufficient to break it; and I kept that fact in view in constructing my machine.

Mr. Cowper :—Then you mean there is a saving of 80 per cent. from not using rollers?

Mr. Buckle :—I do.

Mr. Gibbons :—It appears to me that the principle of this machine is that the *breaking* force acts, by division, upon several points; instead of concentrating all the power to *crush* upon one point, as is done by the roller system.

Mr. Buckle : Precisely so.

The President then requested Mr. William Smith, of Dudley, to read the following Paper :—

ON HIGH PRESSURE STEAM BOILERS, AND ON BOILER EXPLOSIONS.

At the last meeting I laid before the Institution a tracing and description of the steam boiler which recently exploded near Dudley; and although time did not permit any discussion as to the merits or demerits of the construction of that boiler, I think it is very evident that boilers of similar formation and dimensions cannot be safely used for high pressure steam, say 40 to 50 lbs. per square inch. I make this assertion because the great diameter

of the outer shell renders it very liable to be torn asunder by the internal pressure; the internal vertical flue being also of such dimensions that it may be forced out of form and suddenly collapsed by external pressure: and if that system of boiler were to be made safe by a large reduction of the diameter, it would make them insignificant in capacity of heating surface and generating power, and consequently unfit for the purpose they are intended for, namely to use the great quantity of waste heat which escapes from puddling furnaces.

I have prepared the accompanying drawing of a boiler which I recommend in preference to those on the above principle; being much better adapted for generating and for safely containing high pressure steam; and I think more convenient in every other respect for the above system of heating. Fig. 1 is a sectional plan through the boiler, showing four puddling furnaces as I propose placing them to act upon it. Fig. 2 is a longitudinal section through the boiler and descending flue to the chimney. Fig. 3 is a longitudinal elevation of No. 2, with the side view of a puddling furnace at one end, and a section through one at the other end. Fig. 4 is a cross section through the boiler and two furnaces. Fig. 5 is an end view of the brickwork &c.

The boiler is 32 feet long and 4 feet 9 inches in diameter; with two tubes or flue pipes under it, each 36 feet long and 1 foot 8 inches in diameter, and attached to the boiler by three vertical pipes, 10 inches in diameter. The flue pipes are made in a bent form, so as to be highest at the middle and drooping to each end, to keep circulation in the water. The drawing will sufficiently explain every other particular connected with this boiler, so that further description is unnecessary. I shall therefore now only point out a few of the advantages it possesses over the description of boiler before referred to.

Firstly, the diameters of the cylinders being small, they may be made of much thinner plates, and still be perfectly safe with a greater pressure of steam.

Secondly, the heating surface is large and concentrated, without winding flues, so that much steam will be generated.

Thirdly, the area of water surface being much larger, there will be less difficulty in maintaining its proper level.

Fourthly, the steam and water space and heating surface harmonise in their proportions.

Fifthly, the great facility for cleaning out. This is an object of the first importance in the construction of all kinds of steam boilers; as it is well known that, where any difficulty exists in performing that operation, the chances are that it will either be imperfectly done or left undone altogether; which is one cause of many of the fatal explosions that so frequently happen with land boilers.

I do not wish to enter at any length on the theory of explosions; but merely to state my conviction that to one of the three following causes are to be attributed all the accidents to steam boilers:—first, malformation for the working pressure and quantity of steam required; second, want of proper care to fit every boiler with proper steam and water indicators; and third, neglect of cleaning out at proper times. It is a lamentable fact that many boilers extremely liable to accident from one or other of the above causes are still in use; and I think the following reasons will to a great extent account for so bad a state of things existing, in a country too where so much engineering skill may always be procured to rectify defects.

Respecting malformation, I would state that persons about to make erections for steam power generally make the first outlay of capital a leading consideration; and consequently cramp the dimensions of their engines, so that the engines are just calculated to do the work required, with nothing to spare. Soon however some extra machinery is introduced into the establishment; and the engine being found defective in power with the original pressure, an extra load is immediately put upon the safety valves of the boiler; and this process is repeated time after time, as each little additional machine may require the extra power. It follows that the boilers which were prudently arranged to do the work in the first instance are at last a malformation for the increased pressure, and

therefore work in a highly dangerous state; whilst the unsuspecting operatives may be seen crowding round to warm themselves at meal times, when the danger is probably greatest.

Then as to defective steam and water indicators, I have always observed that land engine boilers are not so efficiently fitted with these instruments of safety as marine and locomotive boilers; although I think it is very necessary that they should be so, seeing that a number of them are frequently left to the charge of one individual, with other duties requiring much of his time and attention: whereas the indicators of marine and locomotive boilers are constantly under the eye of one or more engineers, of well proved character and ability for the duties required; and moreover engineers of a higher class are always resident at the principal stations, invested with power to examine engines and to inspect the whole machinery periodically. I have shown on the accompanying drawing all the indicators which I consider necessary for a high pressure boiler in ordinary circumstances. They are as follow:— one feed cock or valve, one float water-gauge with stand and wheel and counterbalance, one glass water-gauge, one steam whistle also for a water-gauge, and two safety valves, one of them locked up. For low pressure boilers I think the open-top feed-pipe, with open pipe for the float wire to work through, is a very perfect apparatus to prevent the steam from rising too high or the water from getting too low.

Respecting the keeping of boilers clean, I have seen that process very imperfectly performed and often altogether neglected in establishments where a sufficient number of spare boilers are not provided and where there is no time to have the boiler cooled down for men to remain in it to do the work properly: but I believe that the greatest cause of neglect in this most important matter is its being generally looked upon as a thankless sort of job; the engineman always looking upon it as an extra duty for which he claims extra allowance, and the master considering that he pays enough to the engineman for that and his other duties. The results consequent upon inattention to boiler cleaning require no comment here; and every practical engineer knows that, if actual

explosion does not happen, the wear and tear upon those parts most exposed to the fire must be greatly increased, thereby keeping up a heavy expense in repairs, independent of the immense quantity of extra fuel that is required to keep up the steam.

I trust that these remarks will suffice to draw the attention of the members of the Institution to this highly important subject; and that the proprietors of steam power may be convinced that the small extra outlay required to make their boilers perfectly safe will be more than repaid by the economy in working.

Mr. Henry Smith said that one disadvantage of the plan proposed was the large amount of room which the boiler would occupy; and that space was often a great object to gain in works.

Mr. Gibbons thought that less space would be occupied than formerly.

Mr. Smith observed in reply that on an investigation the objection would be found not to apply to his boiler, which had something in its favour as to size over the ordinary boiler, though not much.

Mr. Buckle remarked that he had frequent opportunities of observing the reckless manner in which the fitting up of engine boilers was carried on in Staffordshire, to which however there were some exceptions. The upper part of them was generally exposed to the weather, a system which in most cases was attended with ruinous loss. He thought that it would tend greatly to lessen the number of those fearful boiler explosions which had so quickly followed each other of late, and would also be the means of effecting a great saving to the proprietors of the numerous ironworks in Staffordshire and other districts, if a superintending engineer who thoroughly understood his profession were appointed to examine periodically the condition of the engines and boilers employed in these works. It was to him perfectly astonishing that such immense ranges of boilers should be left completely exposed to the weather, as was often the case. In

the year 1832] he was sent for to Bilston, to superintend the renovation of an old blast engine: he had satisfactorily completed the undertaking, when, the season being that of harvest, a thunder storm accompanied by tremendous rain came on; and when he was expecting that everything was right, the engine completely stopped. He thereupon tried the safety valves of the boiler, but not a breath of steam came from them. The steam had become condensed by the exposure of the boiler to the storm; and no excuse could be offered for such gross neglect, as materials for covering were to be had quite at hand and would cost but little. He believed that a handsome fortune might be made by covering up the boilers.

Mr. Fothergill enquired of Mr. Smith whether his boiler was not what was termed a "French boiler."

Mr. Smith replied that it was; he had made them in France.

Mr. Fothergill:—Are they not apt to crack on the upper surface of the lower tube, and on that account subject to frequent complaints?

Mr. Smith:—They never have cracked to my knowledge.

Mr. Fothergill thought that there would be a tendency to crack in the upper surface of the lower tube; and also that greater wear and tear than could be anticipated would be occasioned by the exposure of the lower tube to a greater amount of heat and the action of the fire than the upper one.

Mr. Smith did not think that the tube would be liable to such an injury, because the circulation of water was kept up.

Mr. Cowper suggested the lengthening of the tube, on the principle of lengthening a chimney to get a better draught.

Mr. Smith considered that such an alteration might be an advantage.

Mr. Cowper remarked that, as a protection from the white heat of a blast furnace, there ought to be a parapet wall. He thought that the boiler would be far preferable if parts of it were covered with brickwork.

Mr. Smith said that the operation of the heat on the tube was common to other descriptions of boilers in blast furnaces; and that the operation was not greater in his than in any other case.

Mr. McConnell thought that there should be an indicator to enable the man who attended to the boiler to ascertain when the circulation between the lower and upper tube was impeded. It appeared to him that there was reason to fear that the lower tube might be deprived of water.

Mr. Smith had never seen or heard of such a thing having occurred; neither did he see that it was likely or possible. If the boiler was half filled with water, the tubes were of such dimensions, being 10 inches in diameter, that he did not see how any part could get clear of water.

Mr. McConnell said that accident had actually occurred at the salt works at Droitwich : the lower vessels from a want of circulation were deprived of water, and an explosion took place. In that case there were greater facilities for the circulation of water than were allowed by Mr. Smith. The cause of the accident was the lower vessel being deprived of water, and the consequent rapid generation of steam. Fortunately at the moment of the explosion the men were at dinner; but had it happened only five minutes before, fifty or sixty persons would have been killed; as it was, three or four only suffered. If Mr. Smith's boiler were brought into general use, some detector apparatus should be employed to ascertain whether the upper vessel was doing its duty by circulating the water to the other one.

Mr. Ramsbottom was of opinion that an improvement would be effected in the boiler by making the generating cylinders lowest in the middle, and inverting the direction of the circulation by having the descending current in the centre tube. The greater part of the steam which was generated near the ends of the lower cylinders would not then have to pass along into the centre tube, but would find its way immediately through the end tubes into the steam chamber; the circulation would therefore be much more rapid.

Mr. Smith said that he felt gratified by the various suggestions that had been made. They would induce him to turn his attention to the means of improving the boiler brought before the meeting; but he trusted they were all of opinion that it was infinitely better adapted for its purpose than those now in use.

Mr. Robinson said he should like to know whether in any case heat would injure boiler plates where there was a constant supply of water.

Mr. Cowper said he could take upon himself from experience to answer the question in the affirmative.

Mr. Fothergill said he would take leave to exhibit the drawing of a boiler which had recently exploded in Manchester, sacrificing thirteen or fourteen lives. The boiler showed such singular rents that he had been induced to have a drawing of it made by an artist; and he had purchased the boiler and presented it to the Manchester Mechanics' Institution. The drawing clearly showed the consequences of that kind of boiler getting out of repair; and he considered that the observations of Mr. Smith were most important. Every member would be satisfied that if the sacrifice of life on the explosion of a small boiler, such as he had referred to, was so serious, the result of the explosion of one of a larger class carrying a greater pressure must be fearful indeed, unless proper attention were paid to the protection of the lives of the men who had to attend to them. He was collecting particulars respecting the explosion of the boiler to which he referred; and he intended to lay them before the Institution at some future meeting.

Mr. Gibbons said that, in the cases which had been referred to, the explosions would have been guarded against by a simple indicator like the following:—a gas pipe of any diameter inserted through the top of the boiler down to a safety line in the water, to be acted upon by hydrostatic pressure, so as to show the pressure of the steam and also any deficiency of water in the boiler; these being the two causes from which explosions of high pressure boilers principally arose. This indicator might be of any diameter, say 1½ inches, to be open at both ends, affixed to the engine chimney, and lengthened upwards to whatever height the pressure of the steam in the boiler might require; calculating 2 feet of perpendicular height for every lb. of steam pressure per square inch. Suppose the water to get below the safety line, the steam would rush out at the top of the pipe; and suppose the safety valve to be overloaded or not to act, the water would be ejected at the top, thus giving an

instantaneous alarm to the engineer and workmen. The cost of the whole thing would be very trifling; it could easily be applied, and would not be liable to get out of order.

The PRESIDENT remarked that the suggestion of Mr. Gibbons was not new, for such a pipe had long been known as the alarm pipe.

Mr. GIBBONS considered it was desirable that its utility should be more generally known.

On the motion of Mr. McCONNELL a vote of thanks was unanimously accorded to Mr. Smith for his valuable paper.

The following Paper, by Mr. Charles De Bergue, of London, was then read:—

ON A STATION AND COLLISION BREAK APPARATUS.

The subject to which this paper refers is an improved apparatus intended to act as a Station Buffer or Break, for arresting the impetus of any engine or train that may have entered a station at too great a velocity. It is also proposed to apply the same to luggage vans accompanying trains, in order to lessen the injurious effects of collisions on railways; but first it will be more particularly referred to as a station buffer.

To render a station buffer as effectual as possible, it should combine the four following conditions:—

Firstly, it should move through as much space as, in the arrangement of the machine, is consistent with moderate proportions and economy.

Secondly, its power of resistance at the commencement of the stroke should be rather under the average amount that will drive home the ordinary carriage buffers; say about 3 tons.

Thirdly, its resisting power should be made to increase gradually through the whole range of action, so that before the stroke is quite completed the resisting force should be nearly as much as the under-frames of the carriages would be able to bear without breaking or collapsing; probably from 12 to 16 tons.

Fourthly, it must not have any recoil action after being driven up.

Supposing a train, with a momentum equal to 100 tons moving through 1 foot of space, to come in contact with a station buffer, it would be requisite, to enable the station buffer to arrest the impetus of the train, that the resisting power and the length of the stroke should be in proportion to each other. A station buffer having but 1 foot of action would require a resisting power of 100 tons to arrest the above train; but in this case the carriages would be smashed by the collision: yet if the station buffer were made to move through a space of 10 feet, then a uniform resistance of 10 tons would suffice to arrest the train; but, although in this case a resisting power of 10 tons at the commencement and throughout the stroke might not actually cause the carriages to be smashed, the passengers would receive so severe a concussion that the consequences might be equally disastrous. If the resisting power were made to commence at 3 tons, and were kept progressing in such a ratio throughout the 10 feet, without exceeding 16 tons at the end, that the average resistance would still be equal to 10 tons moving through 10 feet, the train would then be brought up without sustaining any damage. This would be the maximum useful effect that could under any circumstances be produced by a station buffer having a 10 feet stroke with a resistance ranging between 3 and 16 tons. The resisting power of such a buffer would be equal to 1 ton through a space of 100 feet, or to 100 tons through 1 foot; and its power may be increased or reduced by increasing or reducing the length of stroke.

This is the result which has been sought to be obtained by arranging this buffing apparatus, a working model of which is now before the meeting. It is made to a scale of one-eighth full

size; its power and weight are as the cube or as 1 to 512. It represents a strong under-frame of a railway carriage, supported as is customary on wheels and axles. The buffer rods are in the same position as usual, but are much longer and larger in diameter: they are intended to be made of welded wrought iron tubes, $3\frac{1}{2}$ inches in diameter, for obtaining strength without too much weight. They stand out 4 feet at each end of the carriage, and terminate inside in wrought iron racks, the teeth of which are cut out of the solid. These racks must be made of a suitable breadth, and with a pitch of sufficient strength to resist the maximum power they are intended to sustain. The racks of one end of the carriage are turned with their teeth upwards, and those of the other end with their teeth downwards; and they are placed so as to admit the passage between them of the pinions which gear simultaneously into the two racks. A strong wrought iron transverse shaft or axle passes directly across the centre of the carriage, being fitted in bearings in the side beams. On each end of this shaft a wrought iron pinion is formed, which should be forged in one piece with the shaft, the teeth being afterwards cut out of the solid, in order to render them sufficiently strong for the purpose. A friction drum is securely keyed on the centre of this shaft; this drum is surrounded by two steel friction belts, which take about a turn and a quarter round it, being made fast at one end to one of the cross stays, while the other ends are attached to the vertical arms of two levers, the other ends of these levers being subject to depression by the action of two small springs, which are so arranged that when the apparatus is put in motion the pressure on the ends of the levers increases in proportion as the buffer rods are required to oppose greater resistance.

As the model will be readily understood by the members of this meeting, it will be useless to give a minute and tedious description of it; a few general observations will therefore suffice. It will be observed that the principal feature about this invention consists in producing the resisting power of the buffers by means of a friction break, so combined as to effect an increasing amount of resistance throughout the range of the stroke; and that, as this resisting power is effected by mechanical means, it is susceptible of being

modified almost to any extent, as regards its length of stroke and amount of resistance during its range of action; and that it possesses the great advantage of having no recoil.

The model before the meeting is intended, as the under-frame of a luggage van, to be placed between the back of a tender and the carriages composing a passenger train, or at the back of a train on foggy nights, in the event of another train running into it. This model represents 8 feet of stroke for the buffers; supposing the resisting power to average only 10 tons, it would be equal to destroy a momentum of 1 ton through 80 feet, or 80 tons through 1 foot. This would be a considerably more effective buffer than any station buffer now in use. It may be presumed, if a good and powerful buffer could be of any use in a station, that this apparatus must be of some service in a train in the event of a collision; especially when it happens, as it frequently has done, that the speed of the train has been very considerably reduced before the collision actually takes place.

It is intended to make several modifications in the model for its special application as a station break, and particularly to give it more length of action.

Mr. De Bergue at the request of the President explained the construction and action of a model carriage fitted up with his apparatus. It was then resolved to postpone the consideration of the subject until the next meeting.

The President stated that several meetings of the Committee of Council appointed to alter and amend the Rules and Bye-laws, had been held; and that the result of their labours would in a short time be submitted to the Members for their approval.

The Ballot Lists having been opened, it was announced that the following gentlemen had been elected Members and Honorary Members:—

MEMBERS.

W. A. Adams, Midland Works, Smethwick, near Birmingham.
John Bourne, Engineer, 11 Savage Gardens, London.
Frederick Braithwaite, 9 Adam Street, Adelphi, London
John Braithwaite, 39 Bedford Square, London.
David Burn, Busy Cottage Iron Works, Newcastle-on-Tyne.
Edwin Clark, Assistant Engineer of the Conway and Britannia Tubular Bridges, Conway.
Robert Daglish, Jun., Messrs. R. Daglish Jun. and Co., Engineers, St. Helen's, Lancashire.
J. R. Davidson, Aberdeen Railway, Drumduan, near Aberdeen.
Isaiah Davies, Engineer, 44 Bromsgrove Street, Birmingham.
William Denny, Messrs. Denny Brothers, Iron Ship Builders, Dumbarton.
Peter Fairbairn, Messrs. P. Fairbairn and Co., Wellington Foundry, Leeds.
Alexander Fulton, Lancefield Forge, Glasgow.
Thomas Gibbins, Manager of the Battery Company's Metal Works, Digbeth, Birmingham.
Thomas Greenwood, Wellington Foundry, Leeds.
William Hamer, Carriage Builder, Leicester.
Richard Harrison, Engineer, Leeds.
William Hawthorn, Locomotive Engine Works, Newcastle-on-Tyne.
William W. Hewitson, Messrs. Kitson and Co., Airedale Foundry, Leeds.
S. C. Homersham, Consulting Engineer, John Street, Adelphi, London.
Alfred S. Jee, 6 John Street, Adelphi, London.
John Kirkham, Engineer of the Imperial Gas Works, 3 Tonbridge Place, Euston Square, London.
James Kitson, Messrs. Kitson and Co., Airedale Foundry, Leeds.
J. Leather, Engineer, Leventhorpe Hall, near Leeds.
Thomas W. Lord, Messrs. Lord and Brook, Machinists, Leeds.
Walter F. MacGregor, Vauxhall Foundry, Liverpool.
M. McPherson, Marine Engineer-in-Chief to the Emperor of Russia, St. Petersburg.
D. C. Mudie, Messrs. Gourlay and Mudie, Dundee Foundry, Dundee.
John Napier, Messrs. Robert Napier and Sons, Marine Engineers, Glasgow.
Walter Neilson, Messrs. W. Neilson and Co., Hyde Park Iron Works, Glasgow.
Michael Norton, Engineer, Eccles New Road, Manchester.
George H. Philipson, Engineer, 93 Pilgrim Street, Newcastle-on-Tyne.

Wakefield Pim, Marine Engineer, Hull.

Robert F. Reed, Engineer, 1A Terrace Chambers, Adelphi, London.

Michael Scott, Engineer of the Bootle Water Works, Liverpool.

Joseph Shuttleworth, Messrs. Clayton and Shuttleworth, Iron Founders, Lincoln.

William Singleton, Engineer, Leeds.

Edward Slaughter, Messrs. Stothert Slaughter and Co., Avonside Locomotive Engine Works, Bristol.

Joseph Spencer, Iron Founder, Bilston.

Isaac Thompson, Messrs. Kitson and Co., Airedale Foundry, Leeds.

Edwin Turner, Engineer, Bowling Iron Works, near Bradford.

William Vickers, Iron Founder and Steel Manufacturer, Sheffield.

George Wilmot, Erdington, near Birmingham.

Thomas Wingate, Messrs. T. Wingate & Co., Whiteinch Iron Works, near Glasgow.

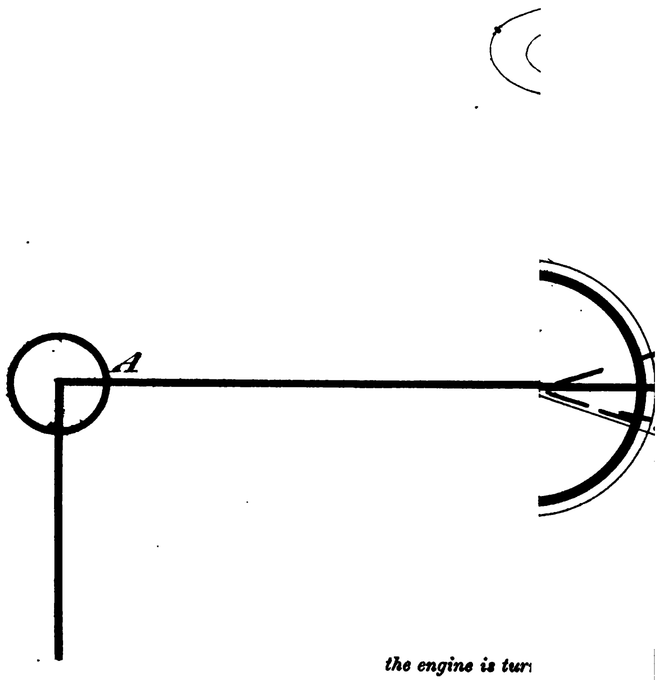
Robert Wood, Engineer, Hunslet Lane, Leeds.

HONORARY MEMBERS.

Captain Huish, General Manager of the London and North Western Railway, London.

James MacGregor, Chairman of the South Eastern Railway Company, London.

Samuel Morton Peto, M.P., 47 Russell Square, London.



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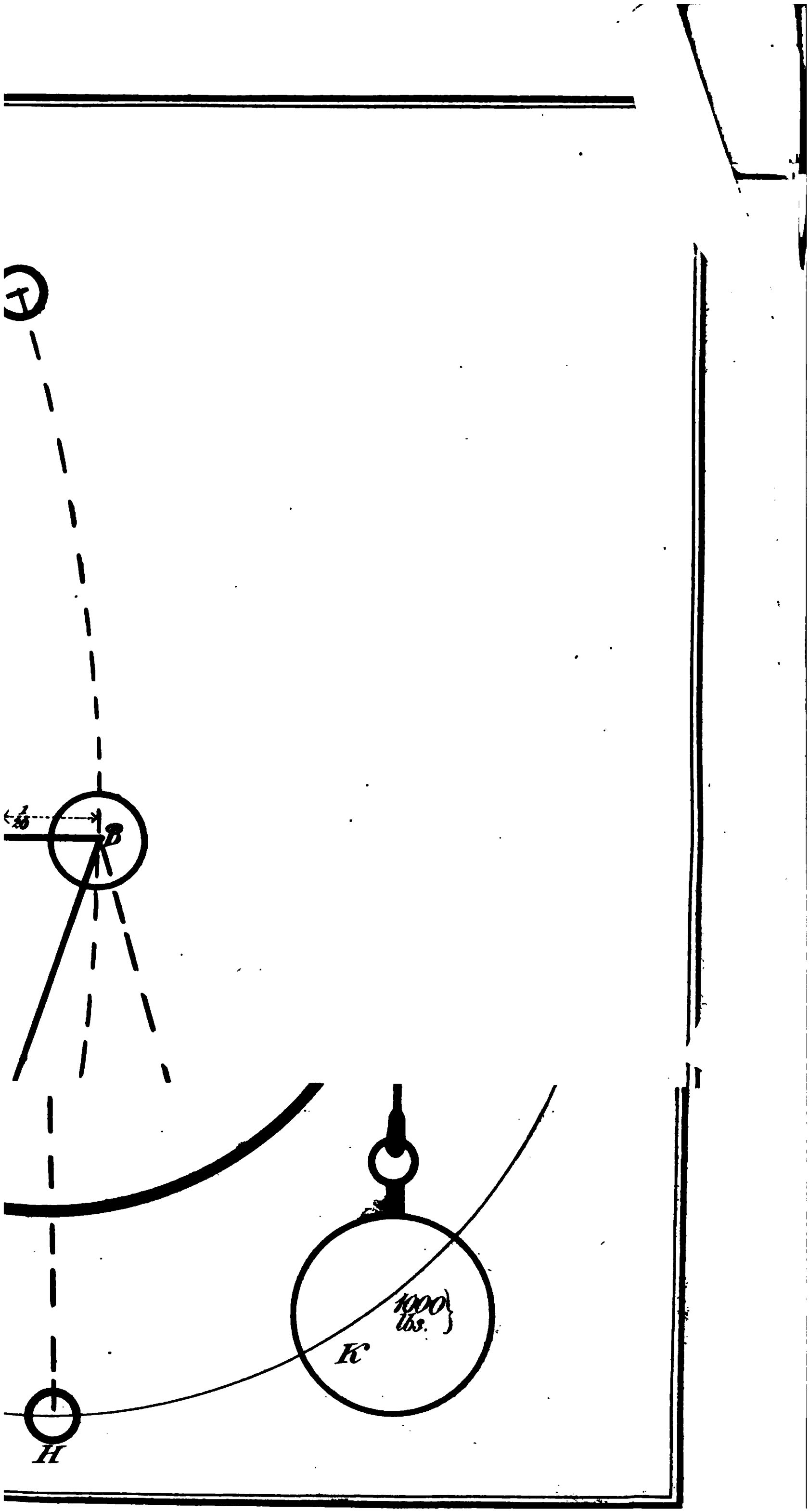
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INSTITUTION

OF

MECHANICAL ENGINEERS.

REPORT OF THE

PROCEEDINGS

AT THE

GENERAL MEETING

HELD IN BIRMINGHAM, ON 25TH OCTOBER, 1848.

J. E. M'CONNELL, ESQ., V.P.,

IN THE CHAIR.

BIRMINGHAM:

BENJAMIN HUNT AND SONS, 76, HIGH STREET.

1848.

PROCEEDINGS.

The usual General Meeting of the Members was held in the Theatre of the Philosophical Institution, Cannon Street, Birmingham, on Wednesday, the 25th of October, 1848; J. E. M'Connell, Esq., V. P., in the Chair.

The minutes of the former meeting having been read by Mr. Kintrea, the Secretary, were confirmed.

The Chairman, in opening the business of the meeting, said they were met for the first time since the death of their late lamented President; an event which, he was sure, all of them deplored most unfeignedly. He was a man who raised himself by his own talents to a distinguished position in society, and whose name, so long as railways existed, would endure. A member of Council, Mr. Scott Russell, had kindly undertaken the task of writing a memoir of their late President, and had intended to have been present, that evening, to read it. The Secretary had, however, received a letter from Mr. Russell stating, that illness prevented him coming; it was therefore left to him, (Mr. M'Connell) to read it.

NOTICE OF THE LIFE AND CHARACTER
OF THE LATE
GEORGE STEPHENSON,
FIRST PRESIDENT OF THE INSTITUTION OF MECHANICAL ENGINEERS;

Prepared, by desire of the Council,

BY J. SCOTT RUSSELL,

ONE OF THE MEMBERS OF THE COUNCIL.

"I wish I could address myself to the business of this evening with a feeling that the duty which you have devolved upon me were less inevitable, or more worthily performed. We have met to deplore the loss, not merely of one of the Founders of our Society, but, also, of a personal friend, whom we have long regarded with reverence and affection. Had these feelings of affection been alone regarded, perhaps our mournful silence would have formed the most expressive exponent of our grief; but the expression of our grief is the least of our duties. In our late President, England has lost one of her most distinguished men,—the world one of its great Benefactors.

"It is not as our President merely, standing as such at the head of the Mechanical Engineers of Britain, that the name of Stephenson will be known to posterity; he will be known to posterity as the presiding Genius of our times; for of this we may be firmly assured, that the times in which we live will be known to posterity as the era in which Railways and the Locomotive Engine were first introduced as elements of social progress. It will be recorded, that about the middle of the nineteenth century Locomotives first began to run upon Railways, and that George Stephenson, the President of the Institution of Mechanical Engineers, was the Man to whose original genius chiefly the world was indebted for the discovery.

"It is difficult for us, to whom the words Railway and Locomotive are household words, to us who live, move, and have our being among Railways and their manifold social results, to go back again, even in imagination, to the beginning of the twenty years ago when were without them. So fast, indeed, we may be said to have lived through those twenty years; so much we have been able to travel over, and see, and learn, and do, that it seems longer to go back over these twenty years, than over centuries of the slower times that went before. We, who have each of us this day come our hundreds of miles to this meeting, and may still have to return hundreds of miles to our homes this night, will find it hard to believe in the records of perils, privations, and delays, which but a few years ago made a journey from Newcastle to Birmingham one of those serious undertakings of life which were anticipated with apprehension, and recollected with congratulation. We now do more work and see more society, acquire more knowledge, by personal observation, in one day of railway life, than we were wont to do in weeks of 'the good old time.' It will be necessary, however, to task our imaginations, and go back to the times before Stephenson, in order duly to appreciate the full value of the benefits which his labors have conferred upon us.

"It is not, however, alone with what George Stephenson *did*, that we are concerned; still more important it is for us to consider that George Stephenson *was*. His title to our gratitude is no doubt great; but his claim to our admiration, as a man, is still greater. As a plain labouring workman we first find him distinguished by his untiring industry, by his zeal for the interests of his employers, and by his steadiness, sobriety, and honesty. We next find him, after having mastered all the details and drudgery of his business, continually on the watch for improvements, cultivating habits of accurate observation, and spending every leisure moment in classifying and comparing the results of his own observation, and in deducing from them hints for future improvement. Did an accident occur in his mine, his whole thoughts were immediately directed to the means of preventing its recurrence. His business, in the humble capacity of a breaksman, took him casually to the vicinity of a condensing steam engine, where the property of his master, through ignorance and mismanagement, was in danger of suffering serious damage. The young breaksman had already carefully studied the nature of its parts, and thought over the principles of its construction; the regular engineer had been baffled in his remedies, and despaired of a cure; but the youthful breaksman confided in the strength of his convictions and boldly undertook the task of refitting the machine; the stubborn engine became at once, in his hands, obedient and useful; he had discovered for himself the secrets of the steam engine; and at five and twenty the young coal-worker had become a Mechanical Engineer.

"Thus early were the results of his self-education manifest. He had mastered the discoveries of Watt. It is true, indeed, his whole life had been one of discovery;

but as yet he had discovered no more than those who had gone before him. His had been the best of all education,—the education which a truth-loving mind, working its way among dead matter, and wrestling with the laws of nature, receives directly from nature herself,—an education far more profound and prolific than words, books, or lectures can ever impart. He had learned the laws of nature at first hand, and by experience; he knew partially what the true properties of matter were; he felt that what they were, was exactly what they ought to have been; and however indefinitively he might be able to give reasons to others for his belief, yet one of the most valuable results of his practical self-education was to give him that implicit confidence in his own right understanding of nature, which carried him so boldly through the herculean undertakings of his future life. The whole first years of his early life were, in this way, one continued chain of discovery. Who can tell the pleasure, or weigh the profit, which such an education bestows on the simple and correct student,—compared to the formality of written dissertations, and the dryness of second-hand knowledge.

"As yet, we have had said he discovered nothing new; but he was now on the eve of making a discovery, the reputation of which has enobled the name of one of our greatest chemical philosophers. A mechanic, James Watt, had already anticipated the philosophers Cavendish and Lavoisier in the analysis of water; and another was now about to anticipate Sir Humphrey Davy in the invention of the Safety Lamp.

"That Stephenson was the original inventor of the Safety Lamp is now happily beyond doubt. Like most other inventions which seem to make their appearance in several places simultaneously, at the moment when the want of them has come to be deeply and generaly felt, the Safety-Lamp seems to have started into being at the same moment, nearly, in London and Newcastle. Stephenson and Davy had both discovered the principle on which they proposed to proceed, before either had made the lamp; *but Stephenson's was made and used the first.* That Stephenson first invented the lamp admits of no doubt, however much the question may remain as to how far Davy may not also be entitled to the merit of equal originality: priority to Stephenson no one can justly lay claim.

"It is as a professional Engineer and a practical Mechanic that we here have chiefly entrusted to us to do justice to the memory of our distingished president. But we should do violent injustice to our own feelings if we were to pass altogether without notice his social character and private life. It is well for us all to recollect, that mere eminence as mechanics, or mechanical inventors, is not enough in the social world to make us either command the love or respect of our fellows. It is as *men*, chiefly, that we respect one another; it is moral character and social virtue for which we chiefly love each other. It has, indeed, been remarked, by some, on the character of our profession, that the continual struggle with tough, hard, and refractory substances, which form the business of the engineer, has the effect of communicating a hardness of character, an obstinacy of disposition, and a rigidity of temper, to men of our craft, which does not add to their excellence as members of society. It must be remembered, however, as a palliative for such faults, where they exist, that every *Inventor* is at first in a *minority of one;* all the rest of the world is, for the time, against him; and it is often only by a long and hard fight that he at last succeeds in converting his minority into a majority.

"Invention is, therefore, a battle with the world; and it is not easy, always, for the inventor to again consider with complacency his enemies in the field, and to adopt them as his companions in the closet. The antagonism between the inventive man and the sceptical world is apt to extend itself to the social state. But Stephenson was, happily for himself and the world, a man endowed with no common share of the endowments which make the intercourse of life useful to himself and delightful to his friends. His energies had been sufficient to carry him through much opposition without cooling the ardour of his affections, originally warm and genial, and, above all, without chilling the enthusiasm, or closing the openness of disposition, which characterized the sanguine youth. In his latter days he was distinguished for the childlike simplicity of his character, for the transparency of his intentions, for the singleness of his purposes, and for the straightforward manly honesty of his conversation and dealings. If he could hate an enemy, he never masked his antipathy by hypocrisy; but he was a warm and earnest friend.

"Greatly, however, as Stephenson's name will continue to be distinguished among us as the inventor of the safety-lamp, and as a youthful mechanic of wonderful shrewdness and sagacity, it is as the first constructor and chief inventor of Locomotives and Railways that he will be known to posterity. It is in this capacity that he has conferred on society blessings which are rapidly extending to the widest limits of civilization, and which already cover Europe and one half of America. The introduction of railways is the great distinguishing event of the thirty years peace; and to them must principally be attributed the strong bonds of amity which are continually drawing nations closer and closer together; it is to railways, and the unity of international interests arising from them, that we are indebted for maintenance of that peace, unbroken for thirty years, and for the very remarkable events we are now witnessing in the existence of a *casus belli* in the heart of Europe, and yet of the invincible reluctance of the great powers to supply the fuel for a general war. The peace of Europe will now, we may trust, by the progress of railways and the consequent multiplication of intercourse, be rendered as substantial as the peace of the nations of the heptarchy of England;—for we have nearly reached that period of railway intercourse, when the capitals of different nations of Europe are not separated so far from one another, either in the length of time, or in the rarity and peril of intercourse, as were the five capitals of the Anglo-Saxon kingdoms of our ancestors: Canterbury, York, and Gloucester were then more distant than are now London, Berlin, and Vienna.

"How all this was early brought about, how much George Stephenson had to do with it, is now too familiar to every mind to need repetition. You all know how he early got permission from Lord Ravensworth and the proprietors of the Killingworth collieries to make an iron substitute for the horses which drew his coal waggons; how he succeeded in driving teams of waggons some six miles an hour; but all of you who recollect these huge unweildy-looking monsters of that early time, and especially those who, like myself, then had to do with them, must remember how little we dreamed of seeing these clumsy affairs go 10 or 20, much less 50 or 60 miles an hour. Indeed, whether we look at the railway or the machine, both would have immediately been smashed to pieces had any force accelerated their speed to 10 miles an hour. It was never dreamed of, except by one dreamer, who believed in 10, 20, 50, and 100 miles an hour, and who had recently determined to do it.

"The two inventions which have been combined to produce the modern Railway system may be said to be, the malleable iron rails and the locomotive engine. These were the two elements of high velocity,—each of which formed the absolute condition of the existence of the other. Without the system of laying a continuous wrought-iron rail, the notion of a velocity of 50 miles an hour could not have been entertained; and without the locomotive engine, such an expensive line could never have proved remunerative.

"Most of us can remember when the idea of laying wrought-iron bars of 50, 70, or 90 lbs. weight per yard, for continuous miles, was an expense so utterly beyond the conception of the time, as not to be entertained for a moment; and this for an obvious reason, that no particular amount of traffic would have paid for it. I think I am warranted in saying, that no amount of traffic which horses, merely, could convey along a line of modern railway could yield a remunerative return, unless, perhaps, under peculiar circumstances, which are exceptional; I am therefore, I think, safe in saying, that the wrought-iron railroad was essentially dependent on the locomotive engine.

"But that the modern locomotive engine could not subsist without the wrought-iron rail and its multifarious appendages of chains, keys, locks, sleepers, switches, crossings, sidings, and turntables, is too evident to need proof. Without the smoothness of the rail, the engine would be jolted to pieces, and without the easy motion which it gives, the engine could not be made to draw a sufficient profitable load to pay; and further, unless made of wrought-iron, it would be impossible to attain the high speed of the locomotive without iminent danger. It therefore appears that the continuous wrought-iron railway and the locomotive engine were inventions intimately related to each other, and each a condition of the other's success. To Stephenson we are indebted for the chief features of improvement in both. It was the joint perfection of the road and the engine which created the Liverpool and Manchester line, and all the progeny of that wonderful and gigantic experiment; an experiment whose complete success now bears incontrovertible testimony to the genius of the man.

"There are several lessons which the life of Stephenson should enforce upon us, the members of a profession which he advanced, and of a society which he so materially assisted in founding, and in the promotion of which he took a constant and deep interest. Indeed, we cannot cast even a hasty glance back over the events of his life, without perceiving that the foundation of our Society was an act most appropriate to the termination of a career so arduous and successful. Let us endeavour to define some of those objects, and then consider how we can best accomplish them.

"In the first place, then, one of the great objects of our Society is the encouragement of mechanical invention and the promotion of scientific improvement. Thus it becomes our duty to supply to this generation a great want, chiefly felt by Stephenson in his early career. The unhappy moments of his youth were those in which his inventions encountered the opposition of prejudice and interest, and when his propositions were decried because of their very originality,—because they were new, strange, unheard of, and, therefore, contrary to verified opinion. What he wanted and could not find in his youth, this Society presents to the youthful genius of this generation,—an enlightended, unprejudiced, and first ordeal, where every youthful inventor, every mechanic of original talent, every proposer of that which is new and promises to be useful, will find a body of experienced practical

men, to whom the country looks up as her wisest men, ready and willing to listen to the plans, to test the proposals, to weigh the value, and to award the praise and approbation to which the rising Stephensons of this generation may aspire; but which the old Stephenson could no where find, and in the want of which he was compelled to expend many years of vigour and energy in obscurity and penury. Let us see that in our hands no youthful genius, however little known, shall find his genius obscured, or his energies discouraged, eclipsed, or extinguished. If I rightly interpret the feelings of this Society, they would hail with welcome any discovery, and cooperate heartily and disinterestedly in giving to the world its benefit, and to genius its honors and rewards.

"Another circumstance must have greatly impaired the means of usefulness of Stephenson in his early life, and one that he most deeply felt,—viz., the want of knowing that which other men were doing, and had done before him, in subjects allied to those in which he was occupying his mind. Thus much we know with certainty, that no man was more happy to communicate, in after life, to others the abundant stores of practical knowledge he had accumulated, and that no one felt a more kindly interest in the inventions and plans of younger men, or was more disposed to promote their interest and forward their views. Let us regard it as a part of his legacy so to impart, liberally, to all younger members of the profession, what more knowledge or greater experience may have enabled us to acquire. After all, there is no tribute more gratifying to the members of our profession than the due appreciation by each other of that which each of us may have done to advance the interests, and increase the resources of mechanical science.

"It would not be fair to the character of our late President to omit from our recollection the very large and original views which he entertained on general science. It has been too common in our profession to place science and practice in opposition to one another; as if true science and hard practice could possibly be opposed. If science mean that which is carefully ascertained, and accurately defined, and truly demonstrated,—then it is impossible that any sound practice can possibly stand in opposition to, or independent of, it. If practice mean the knowledge which is founded on the actual facts and experience of intelligent men, it is impossible to see how the largest amount of that knowledge possessed by any one man can differ from the extensive and generalised facts in which science embodies the experience of all mankind. Stephenson is a remarkable freedom from this prejudice. He was eminently a practical man. He wrought early, and much, with his own hands. He had wrestled with matter, and knew all its qualities by feeling it and pushing it and pulling it, by cutting and filing and chipping it. He had hammered it hot and hammered it cold, he had melted it and moulded it, planed it and sawn it, broken it across, pulled it asunder, and twisted it round. He knew its action and its reaction, its inertia and its momentum, its *vis mortua* and its *vis una*. His was a supremely practical and personal acquaintance with the laws and property and phenomena natural to matter, whether solid or liquid, fluid or gaseous, mineral or aerial, more than any man who has ever risen to eminence. Stephenson was entitled to rank as a consummately practical man. But was he not equally, or more, a scientific than a practical Engineer? Was there ever a bolder theorist than he was? Were there ever more daring scientific speculations than those wild flights in which his genius delighted to break forth? In chemistry, in vegetable physiology, in vital mechanism, in electricity, in galvanism, in the theories of the gases, on the inert constitution of matter, and of heat, and even

on the mechanism of the mind itself, he had deeply thought, profoundly read, and boldly and fearlessly speculated. Every step in his life was the realisation of what had before been a theory. It is true he was not educated early in the rudiments of science, at school or at college; but what of that? what is life but a great school? Is not the press our school, and necessity our school of invention? Stephenson read and studied science;—he was not ignorant, but he was self-taught. Before he became a great man he had studied profoundly, and he does not appear to have ventured on any construction or invention, before having accurately, and generally truly, calculated by the principles of science, its probable and actual results. In all his works, Stephenson exhibits to us embodiments, eminently practical, of the profoundest principles of mechanical science. Let the men among us who desire to emulate him most, endeavour to combine, in the greatest degree, the truest science with the soundest practical sense. These are not times in which any of us can afford to dispense with any science, or any practice, that it may be in his power to obtain.

"I will now venture upon an illustration of the advantage of uniting high science with extensive practice, which has often occurred to me as an excellent illustration of Mr. Stephenson's scientific knowledge, and also as an illustration of the advantage he would have derived, as a practical man, from having been still more profoundly scientific than he was. Stephenson, we know, invented the fish-bellied rail, and a great invention it was thought in its day. The Liverpool and Manchester Railway was opened with it. It was an invention to give, with a small addition of metal to the under middle side of the rail, nearly double the strength, and this it successfully accomplished. But here he stopped short: he had not science enough to see, that by making the wrought-iron bar in long lengths, stretching over a number of blocks, or sleepers, he had brought it into a new condition, to which a much higher rule was applicable;—he neglected the difference between a rail having a joint at every chair, and one having only a joint at every fifth or sixth chair; had he perceived that, he would have invented the parellel rail, and would have learned that the joint chairs require to be nearer together than those removed from the joint by a fixed proportion. The fish-bellied rail was a failure. It was the result of science; but of science of which there was not enough. It was also the result of practice; but of practice under different conditions. It was reserved for Mr. Buck, a profoundly scientific pupil of Stephenson's, to develope the true science of the wrought-iron rail. Where not a little science had failed, a little more made the invention perfect. Let us learn from this to be always trying to obtain a little more science, as well as a little more practice, than we have got,—remembering that Stephenson continued his education of himself to his dying day.

"The best testimony, however, which Mr. Stephenson has borne to the value of scientific education for a practical man, is to be found in the course he adopted for the training of his son to our profession. The assiduity with which he laboured at clock-making, the cleaning of watches, or any other industry, in the intervals of his regular business, in order that he might be able to afford to him those blessings of education of which he himself so deeply felt the want, is one of the most charming features in his character. His most earnest desire, in early difficulty, was to give Robert all those precious thoughts and truths which he himself only acquired late and too labouriously. And how admirably his plan succeeded, his son's unclouded successes, both as a Mechanical and a Civil Engineer, are the

evidence to us, as indeed they were the subject of just pride to himself, who never spoke of his son without strong emotions of joy and pride. There are none of us who will question either the justice of his pride or the soundness of his plan of education.

"It is one of the peculiarities of genius to inspire those within its influence with some of its own fire. This was peculiarly the case with Stephenson. Nearly all the present ornaments of our profession have been his pupils. He was the founder of a school of eminent engineers, who in England, Europe, and India, are now extending, amongst all portions of the human race, the blessings of those great bonds of civilization and social intercourse which he first fabricated. It is to his labours, and theirs, that this country owes the addition of £200,000,000 to its productive wealth, the opening up of a host of new branches of industry, the quickening and invigorating influence of rapid and cheap intercourse; and to him that the poor everywhere owe the blessings of cheapened coal, and the facilities of social enjoyment and healthful recreation.

"In this brief notice of the chief features and character of our late president, which I have thus imperfectly, although most earnestly, sketched amid the bustle of business, I have dwelt mainly upon such features and characteristics as were peculiarly interesting or instructive to us, as members of an institution founded, in a great measure by himself, for professional purposes. I have regarded, therefore, chiefly his professional character; but I cannot conclude without expressing an earnest wish, that his life as a man, exhibiting the beauty and excellence of his character in all its cheering aspects, as a boy, as a workman, as an engine-man, as a viewer, as an engine builder, as an improver of mineral railways, as the engineer of the Liverpool and Manchester Railway, should be written by some one who has leisure to collect from his many friends all their recollections of him, while they remain fresh and accessible. I should desire also to see a detailed account given of his progress, his difficulties and his means of success in any one of his labors. This would be a most valuable and instructive work; and I do not know on whom it should devolve more properly to see such a work executed faithfully and judiciously than on this society, whom he made the favoured recipients of his knowledge and experience, and who ought to consider themselves as his literary and scientific executors, to whom the world may naturally look to see justice done to the memory of one of England's greatest men, the founder of our railway system and of the Institution of Mechanical Engineers."

The memoir, which, both at the close and during the time of reading, elicited expressions of admiration, having been read, the CHAIRMAN said, he presumed it would be unnecessary to put it to the vote, that the members return their best thanks to Mr. Scott Russell, for his very able memoir. The vote was carried with acclammation.

Mr. GEACH rose and said, it was with melancholy satisfaction he begged to move, that they place on the minutes of their proceedings an expression of the regret they all felt at the loss of so excellent a man as their late friend, Mr. George Stephenson,—apart from his having been the President of this Institution. He

well recollected Mr. Stephenson, on the last occasion of their meeting, filling the place which Mr. M'Connell now so worthily occupied, in high spirits and in good health. The recollection of the circumstance cast a gloom over his feelings, and he was sure it would have the same effect on every member present. He had known Mr. Stephenson a shorter time, perhaps, than many of them; but he had known him well enough not only to entertain respect for him, but affection also. There was something so endearing about his manners, so open and kind, and so encouraging to all those less experienced than himself,—there was so much of kindheartedness about him, that no one could help entertaining for him a high respect. He would quite allow that his manners were sometimes rough,—he would quite allow that there were peculiarities in his character, which had to be considered as peculiarities; but he was quite sure those who knew him best considered that these very peculiarities gave him a greater claim on their regard. He was willing to allow that he had seen in Mr. Stephenson what in other men might subject them to criticism; but when it came from Mr. Stephenson, it came from a privileged person. Mr. Stephenson was proud of his own early life, and he never lost any opportunity of expressing it,—he never attempted to conceal that he came from the lowest grade of society, and had raised himself to his high station; and he ever evinced the same pleasure in meeting an associate of his early life, in humble circumstances, as he did to meet the peers of the realm, with many of whom he associated in later life. He had the same gratification on meeting one whom he had known in early life, or the son, or connection, of such a one, and in referring back to the time when they had struggled together through difficulties, as he did in referring to the occasion when he was taken by the hand by the highest in the land. Although oppressed with these recollections, he could not content himself without making the few remarks he had; and he now begged to move,—
"That the members of this Institution desire to express their deep regret at the decease of their late President, George Stephenson, whose early support of the Institution so greatly contributed to bring it to its present state of prosperity and success."

Mr. Fothergill, in seconding the resolution, expressed his great sorrow that such a duty should devolve on him. After the

observations of Mr. Geach he should content himself with merely seconding the resolution, for he was sure that every one participated in the same feelings of deep regret. The resolution was put and carried unanimously.

The CHAIRMAN then rose and said, that immediately on hearing of the death of their late President, the Council met, at Manchester, and, after forwarding a letter of condolence to his widow, for the irreparable loss she had sustained, they resolved, that the best tribute they could pay to the late Mr. Stephenson's memory, and the best way in which they could testify their appreciation of his merits, besides at the same time the best selection of a future president they could make from among the eminent men of the day, would be to invite Mr. Robert Stephenson to become his father's successor, as president of this institution. The Council did so feeeling assured that the members would entertain the same opinion. Accordingly, two of the Council were appointed a deputation to wait on Mr. Stephenson. Owing to an accident they were prevented from seeing Mr. Stephenson, but a most satisfactory and pleasing correspondence ensued, which would be read by one of the deputation. Afterwards it would be his duty to nominate Mr. Robert Stephenson, as the future president.

Mr. FOTHERGILL said, that Mr. Buckle and himself were the deputation appointed to wait on Mr. Stephenson; but for the reason stated by the Chairman, they had not been able to see him. They had, however, a correspondence, and Mr. Stephenson's reply did equal credit to his character as a man, and to his feelings as a dutiful son. He had not the letter with him; but the substance of it was, that, if elected, nothing would be wanting on his part to discharge the duties of the office in a manner satisfactory to the members, and that he would endeavour to watch over the interests of the Institution as earnestly as his lamened father had done.

The CHAIRMAN then begged to propose Robert Stephenson, Esquire, as President of the Institution. He felt certain that every member would agree with him, that a better choice could not be made. Mr. Robert Stephenson was a worthy son of a worthy father; and the Institution would gain additional lustre by having that gentleman as its President. The resolution was

seconded by Mr. Fothergill, and carried unanimously, amid every demonstration of satisfaction.

Mr. KINTREA, the Secretary, then read the following paper by Mr. John Jones, of Bristol:—

"ON THE ADAPTATION OF THE 'CAMBRIAN ENGINE' TO LOCOMOTIVE PURPOSES.

"The following is a brief description of the advantages to be derived by the application of my Patent Cambrian Engine to locomotive purposes. One has already been made by Thwaits and Co., Engineers, of Bradford, named the 'Albion,' which, I understand, gives every satisfaction.

"On refering to the drawings which accompany this paper, it will be seen that the side elevation, No. 5, shews the side levers as connected to the wheels. The levers are fitted on to the ends of the piston shafts, which work in separate bearings; from the opposite ends of these levers pass connecting rods to the crank pins on the leading and centre driving wheels; on each side of the engine, the pistons communicate an oscillating motion to the double levers, the length of which is so adjusted as to cause the driving wheels to make whole revolutions; by this arrangement the strain of the working parts is balanced: there is no centre pressure, and all dangerous oscillation is completely avoided.

"Another advantage derived from the mode of connection, is the oscillating lever ends passing through a great part of a circle, gaining power, as it does, at the extremities of the stroke, to compensate for the loss of power in the cranks, as they approach the dead centres. The circle that the crank pin centre moves through is divided into twenty parts.

"It may be seen by the diagram that, as the lever approaches the extremities of its stroke, the actual length diminishes, and becomes from 18 inches to 17¾ 16, 15¼, 14, and 13¼ inches at the centres, so that the power of the lever increases in proportion to its diminution in length; which compensates in a great measure for the loss of power in the crank, as it approaches the dead centres.

"I presume the principle of the 'Cambrian Engine' is tolerably well known, as it has now been before the public upwards of seven years; several having been at work for more than six years, to the entire satisfaction of the parties using them. I therefore feel satisfied as to its superiority over the common cylinder engine, as the wear and tear is much less, in consequence of there being fewer working parts.

"I have now pointed out what I consider to be the advantages of this engine; viz:

"Obtaining a long stroke in the crank, without the disadvantages of a long stroked cylinder, where high velocities are required.

"The arrangement of the levers which balance the engine.

"The entire disappearance of any oscillating motion of the engine.

"Doing away with all centre pressure, an object of the highest importance, and one that deserves more attention than it has hitherto received.

"JOHN JONES,
Great Western Iron Steam Ship Works,
Bristol, 11*th October*, 1848."

In the absence of Mr. Jones, and at the request of the Chairman, Mr. E. A. Cowper, with the assistance of diagrams, further explained the construction of the engine, commonly known as the "Cambrian Engine;" but added, that as applied to locomotion he had never seen it until that morning. In answer to numerous questions Mr. Cowper stated, that although he did not altogether recommend the "Cambrian," he had often known it to work satisfactorily. As compared with ordinary engines he could not see any great advantage in it.

In answer to a question, Mr. SLATE stated that he had had some experience with rotary engines, which the Cambrian engine somewhat resembled, and the conclusion he had come to was by no means favourable to that principle. At the same time, he did not see any difficulty with Mr. Jones's patent; and as far as he could perceive, the difference between it and the ordinary engines consisted in the fact, that the "Cambrian" had the advantage of having the principle weight between the wheels, whereas, by the ordinary arrangement, the weight was in front of the driving wheel. In other respects, the "Cambrian" very much resembled the locomotive lately made by Mr. Wilson, of Leeds; the principle difference being, that in the latter there was a strain on the bearing of the centre shaft, which he did not find in the former; otherwise, the action of the balancing of the engine was exactly the same.

Mr. CRAMPTON said, there were two bearings of the shaft to which Mr. Slate referred. He had paid some attention to this matter, and he thought that the intention was to balance the engine, or locomotive, with the momentum of the parts, so as to avoid oscillation. He would show a practical objection which he conceived to exist: suppose three shafts in a right line, with a lever for the centre shaft, and a crank on either side; when in a perfectly straight line, the lengths remained the same; and if on a table, or on any perfectly smooth surface, it worked as sweetly as possible. On a railway, however, supposing there to be three wheels, and the road to be a little out of order, the one shaft would be thrown out of the line referred to, and as the spring deflected $\frac{3}{4}$ of an inch, it would have the tendency to lengthen the connecting rod, which could not revolve past the

centres without straining the parts, but which, with the ordinary connecting rod, would produce no bad effect.

The CHAIRMAN said, that there certainly seemed to be an objection; in fact the line of the three centres would be destroyed.

Mr. CRAMPTON :—The thing works perfectly when the parts are in one line; but as soon as they get out of the line, there is an undue strain.

In reply to Mr. Peacock, Mr. CRAMPTON admitted that additional bearings might be put on to the axles of the wheels, with cross bars to carry the cylinders and bearings of centre shaft; but it would be found to involve an extra ton or two in weight, which could not be afforded.

Mr. PEACOCK :—In the case of Wilson's Engine, where there were only axles, shafts, and cross bars, the objection would not be so great.

The CHAIRMAN :—It would be greater in the Cambrian engine than in Wilson's; because, in the former there is a cylinder to support.

Mr SLATE did not see that a little extra weight between the shaft and the cylinder would be of material effect, it being supported from the axle. If it supported five cwt. it could support fifteen. Perhaps Mr. Peacock would favor the meeting with his opinion of the oscillating shaft?

Mr. PEACOCK had not had sufficient experience; but as far as he could see, it appeared to work beautifully. As to the outside levers, he had heard no complaint of inconvenience; in fact, it must be a very serious thing that would cause the shaft to deviate an inch from the right line, and then it would be but for a moment. In Wilson's engine, the shaft was supported from the frame of the boiler, and when the whole weight of the engine was on the springs, they might imagine the three shafts, or centres, to be in a right line,—and any deviation from it would be but for a moment, as it would immediately regain its position, unless the springs were broken. From his experience of Wilson's engine, he had no objection to the levers being outside; but how long these might stand, was a different thing.

Mr. CRAMPTON had never seen any engine work so beautifully and steadily as Wilson's locomotive. His objections were principally of a practical kind. He maintained that that engine could

not be kept right for any length of time. It was inherent in it to increase or diminish the length of the connecting rods by $\frac{1}{8}$th of an inch. In the actual working of a railway, the engines could not always pass under the observation of the superintendent,—and hence durability was a matter of great importance. At the same time, he must tell them what he had seen,—and on an even surface he had never seen a steadier working engine. All the weight was between the two rods, which he considered to be the great reason why the oscillation was avoided.

Mr. SLATE gave it as his opinion, that, with reference to the question of the form of the cylinder, he could not see that the form of the vessel was of any particular consequence, so that the space be filled with steam. The power derived will be just equal to the quantity of steam contained in the cylinder. In that view, he saw nothing to object to in the circular form of the Cambrian's cylinder; and, otherwise, the engine under consideration had good points. The outside levers and the two cranks worked admirably; and the only question was whether it would support a cylinder of the weight required between the two shafts. He saw no objection to the application of the "Cambrian" to locomotive purposes; but he did not feel quite competent to give a positive opinion.

Mr. COWPER said, that Mr. Crosley, a party interested in the engine, had told him that it had been tried on the line between Birmingham and Derby, and that it not only burnt five pounds of fuel per mile less, but took a heavier load than any other engine.

Mr. HUMPHREYS was rather inclined to think that it would go forth that the principle of the invention had met with the approbation of the meeting; but, as far as he had been able to discover, he could not see any reason why steam applied in this particular way should do better than in the ordinary way of a simple cylinder. As Mr. Cowper had had considerable practice in steam engines, he wished to know, if, in making a steam engine, he would be disposed to adopt Mr. Jones's plan?

Mr. COWPER begged to guard himself against the supposition that he saw any advantage in the plan, or in the form of the cylinder.

Mr. HUMPHREYS could only record his own opinion, that no possible advantage could be obtained by so applying the steam;

but, on the contrary, a disadvantage; for they had to get over the difficulty of connecting all the joints.

Mr. COWPER said, the cylinder was perfectly tight.

Mr. SLATE did not consider that, in the absence of Mr. Jones, they were in possession of sufficient information to enable them to arrive at a decision on the merits of the patent. At present, they had no particulars as to the size of the engine, the pressure of the steam, the size of the connecting gear, and various other matters.

Mr. P. R. JACKSON expressed it as his opinion, that the Rotary engine was a far better application to locomotion than the Cambrian engine. He well recollected a gentleman calling at his foundry, in Manchester, some years ago, and in compliance with that gentleman's request, he cast for him the parts of a rotary engine; at the same time expressing his opinion, that it would do no good. The engine, however, was completed; it cost the inventor £400, and in two years afterwards it came back to him for £14.

Mr. COWPER remarked, that the objections of Mr. Crampton extended to the coupling of any engine; for as one wheel went up, and the other down, the connecting rod must vary. It did not hold to the same extent in all cases; but still it did hold.

Mr. SLATE inquired, whether the objection might not be overcome by making the guard plates a little larger?

Mr. CRAMPTON replied, that this was being done; but he conceived there was a still greater objection to that alteration.

The CHAIRMAN thought they had not sufficient data before them as to the economy of the engine, or even as to its adaptation to the purpose designed, to enable the meeting to form a correct opinion. He therefore presumed that, at present, it would be premature to come to a conclusion as to its merits.

Mr. BEYER gave it as his decided opinion, that the ordinary straight cylinder would work better than the curved one of the Cambrian.

The CHAIRMAN then requested Mr. Fothergill to read a paper communicated by Mr. W. L. Kinmond, of Dundee.

"DESCRIPTION OF A RAILWAY CARRIAGE ELEVATOR,

"*Constructed for the Glasgow and Ayr Railway Company, in* 1840.

"The Glasgow terminus of the Glasgow and Ayr Railway is 20 feet above the level of the street, and the elevator was constructed for raising and lowering the goods trucks to and from the level of the goods warehouses and the street.

"A, as marked on the drawing, is a travelling platform of sufficient length and breadth to receive one goods truck; on the upper side are two rails, which coincide with the rails in the station. When the platform is at the top, or bottom, it forms a hatch in the floor of the station, upon which the truck to be lowered or raised is placed.

"The machine is supported, at the corners, by four large cast iron columns, joined together, at the top, by cast-iron beams, which are strengthened by ornamental brackets, presenting the form of an arch on all the four sides; the whole resting on a substantial foundation of masonry. The driving machinery is all placed below the level of the warehouses, or immediately beneath the platform, when at the lowest point.

"B is the main driving shaft, communicating motion, through the friction wheel, to the mitre wheels d e, and, by a reversing clutch, to the shaft g. When the platform has to be raised, the clutch is geared with the wheel d, and when it has to be lowered, the clutch is geared with the wheel e: the intermediate shaft K transmits to the shaft 1 a motion corresponding with that of the shaft g. Four pairs of mitre wheels, at the extreme ends of the shafts g and K, give motion to four upright shafts, reaching from top to bottom of the elevator. On these shafts are four screws, made to revolve with the shafts, and, at the same time, to slide freely up and down on them by means of a groove in the shaft, and a feather, or fixed key, in eye of screw.

"Four plumber blocks are bolted to the sides of the platform, and are its resting points upon the screws. These plumber blocks also serve to steady the screws and upright shafts at their points of action. A bracket, bolted to the platform, secures the screws in their places. The screws act into four circular racks, extending from top to bottom of the machine, and are constructed to turn freely on their axes, along with the screws, the peripheries of both going at the same velocity, thereby saving a great amount of friction. The racks are steadied by two intermediate bearings, which do not at all interfere with the working. From this arrangement it will be observed, that when the screws are turned one way, the platform rises, and when turned the contrary way, it is lowered.

"Supposing the platform to be at the bottom, it is put in motion, upwards, by means of a handle in the socket p. The rocking shaft g, by means of the spanners and connecting rod o n, moves another rocking shaft r. On the other end of r is a lever, which throws the clutch into gear with the wheel d; thus giving the proper motion to the screws for raising the platform.

"It will be noticed, that the same movement that turned the rocking shaft r, moved backward, the rod t, bringing the point q, of the rod, within range of the eccentric v, which slide on a key on the intermediate shaft. In its present position it would revolve without touching the point q of the rod t, but when the platform reaches the top, it touches a catch on the upright rod w, moves the rod x forward, and the pin attached to the rod sliding in the angled slot y, causes the end of the rod to move laterally, and the rod being connected with the eccentric, brings it into contact with the point q of the rod t, sweeping it back in its former position, and the machine is again out of gear, and at rest.

"This machine can be stopped at any point of its ascent or descent. There is a friction break to be used, should the platform gather too much way in descending, or to hold on with, in case of anything giving way.

"The weight of the platform is balanced by weights, suspended by means of chains over pullies inside the main columns.

"The Elevator is driven by a six-horse engine, and lifts from eight to nine tons; the time taken to rise from the bottom to the top is about one minute. It has been in constant use ever since its erection, and has given great satisfaction, the screws and racks having been only once renewed.

"WM. L. KINMOND,
Wallace Foundry,
Dundee, 21*st October*, 1848."

At the request of the Chairman, Mr. SLATE, who had traced the reference to the diagram, during the reading of the paper, said, that, in the view he took, this elevator appeared to embrace everything that was necessary to safety and efficiency. The front elevation of the driving gear was ordinarily such as he had seen in the old kind of planing machines; and the contrivance with a view of stopping it from descending was a very ingenious application of different forms of lever and connecting rods. The action seemed to him to be perfect, and it was impossible that it should not be under the complete control of the breaksman.

Mr. FOTHERGILL said, it appeared to him that the principal feature was the character of the revolving rack. The thread of the worm of the screw kept pace with the revolving rack, and thereby prevented any great friction.

Mr. HOBY thought Mr. Fothergill had pointed out the best feature in the Elevator. The question was, which was the best kind of hoist. He saw it when it was first put up, and it worked remarkably well. The one on the Manchester and Leeds Railway was worked by flat ropes.

Mr. CRAMPTON had also seen it at work; but did not take particular notice beyond that it worked well.

The CHAIRMAN presumed that he might take it as their opinion, that it was a very good application of the revolving rack. He saw it within six months of its erection, and was very much pleased with it. He had recently been told by Mr. Robertson, the locomotive superintendent of the line, that it worked very well indeed,—never having required repairing except in one instance, and that some time ago.

A vote of thanks to Mr. Kinmond was then passed, for his interesting paper, the Chairman adding, that it was very desirable to encourage these communications from distant members.

Mr. Cowper then read the following extracts from Mr. Wicksteed's printed report on Brockendon's application of Vulcanised India Rubber to pipe joints.

"On the 22d of May, experiments were tried upon the new rings and filletted pipes:—

"Exp. 5th, 4-inch joint, spigot *without* the upper fillet, stood 658 feet pressure, and gave way under 733 feet.

"Exp. 6th. 4-inch spigot *with* it, stood 1241 feet pressure, and was not tried farther.

"Exp. 7th. 9-inch, spigot *without* the upper fillet, stood 733 feet, but worked and leaked very slightly from 240 feet pressure and upwards.

"Exp. 8th. 9-inch, spigot *without* the upper fillet, stood 755 feet, leaked as before, and blew out at 945 feet pressure, *after* 4 or 5 strokes of the pump.

"Exp. 9th. 9-inch, spigot *with* upper fillet, stood 1241 feet, at 945 feet it worked and leaked very slightly, and continued to do so at 1241 feet, but it did not blow out, the belt preventing it.

"Exp. 10th. 12-inch, spigot *without* the upper fillet, stood 733 feet, and at 900 feet, after working the pump for some time, it gave way.

"Exp. 11th. 12-inch, spigot *with* upper fillet, stood 600 feet, the ring was so thick that it could not be made to enter the joint properly, and, when joined, the ring oozed out past the belt, so that no fair trial could be made.

"Exp. 12th. 12-inch, spigot *with* upper fillet, stood 1333 feet, the ring was again too large, and if it had not been kept in by the belt would not have stood the pressure, the ring oozed out all round the joint, but stood the pressure without leakage. After a few strokes of the pump, however, the iron pipe burst. The pipe was 9·16ths of an inch thick, but there was an air-bubble flaw in it.

"After a variety of Experiments tried in the months of April, May, July, and August—some in the presence of Mr. Brockedon and Professor Cowper—the proper thickness of rings and forms of sockets and spigots were determined on, and the following very satisfactory results were arrived at.

"Exp. 13th. The 12-inch stood a pressure of 600 feet, and at first 900 feet, but after working the pump for a short time it gave way.

"Exp. 14th. The 4-inch stood a pressure of 1333 feet, without giving way at all.

"This result shewed that the rings of the 12-inch were too light, and that the 4-inch, although it stood the greatest pressure, appeared to enter the socket too easily; I, therefore, proposed to increase their weight to 4½ ounces and 1½ ounce respectively.

"Upon July 31st, 1848, the new rings were tried, the 12-inch weighing 4¾ ounces, the 4-inch 1½ ounce.

"Exp. 15th. The 12-inch stood a pressure of 900 feet, but after several strokes of the pump at a pressure of 1333 feet, it blew out at a defect in the upper fillet on the casting.

"Exp. 16th. The 4-inch stood a pressure of 1333 feet without giving way at all.

"Exp. 17th. The 12-inch stood a pressure of 1333 feet.

"Upon the 15th May, the five 4-inch pipes were joined together without fillets on the pipes, and with the rings supplied at that time as hereinbefore described as imperfect. These joints have been exposed to a varying pressure of from 90 to 175 feet to August 21st, being a period of above three months, and they are now perfectly tight, and no change has taken place.

"The time occupied in these trials has been above five months, and I am now enabled to speak very confidently of the value of the new joints.

"It appears that, for a 4-inch joint, the space between the spigot and socket being ¼ of an inch all round, the Vulcanised India Rubber ring should weigh 1½ ounce, and for a 12-inch ring the space between the spigot and socket being the same, viz., ¼th of an inch, the weight of the ring should be 5¼ ounces.

"The spigot and socket ends of pipes to suit the Vulcanised India Rubber rings should be formed as follows:—The depth of the socket for all pipes up to 12-inch, which is the largest I have experimented upon, should be 3½ inches; the thickness of the joint or space between the outside of the spigot and inside of the socket, should be ¼th of an inch. There will be no occasion for extra strength in the sockets, as they are not exposed to any blows or to the force of the wedge in making the joint, as in lead or wood joints. The spigot should have a bevelled square head or belt 3·16ths of an inch thick, and ½ an inch deep, cast on the end, then a clear space of 2½ inches, and another belt of the same dimensions.

"I have calculated the weight and cost of 100 rings of various sizes, which will be the number required for 300 yards of pipes, as follows:—

	Weight. lb.	oz.	Per lb.	£	*s.*	*d.*
3 inch	7	0	@ 5*s.*	1	15	0
4	9	6	..	2	6	10½
5	12	5	..	3	1	6¾
6	15	4	..	3	16	3
7	18	3	..	4	10	11¼
8	22	2	..	5	5	7½
9	24	1	..	6	0	3¾
10	27	0	..	6	15	0
11	29	15	..	7	9	8¼
12	32	14	..	8	4	4½

"To make a comparison between the cost of the India Rubber joints, and lead or wood joints, I have in the following statement included the *material*, the *labour in making the joint*, and the *excavation*, and *filling in of the trench* only, but including 10 per cent. profit.—

	Lead per yd. run *s.* *d.*	Wood per yd. run *s.* *d.*	Vulcanised India Rubber per yd. run *s.* *d.*
4-inch	6 6·10ths	4 6·10ths	3 3·10ths
12-inch........	1 7	11	9 9·10ths
3, 4, 5, 6, 7, 8, 9, 10, 11, 12 in. one yard of each	10 0	6 2	5 2

"Taking one yard of each sized pipe, from 3 inches to 12 inches inclusive, and in addition to the above, adding the average cost of *carting the pipes to the trench, removing surplus earth, repairing drains, lead pipes, &c., and all other charges and risks, and guarantee for twelve months,* EXCEPTING *the charges of the Commissioners of Roads or Streets for paving, &c.*, the cost will be as follows:—

Lead.	Wood.	India Rubber.	India Rubber cheaper than Lead.	India Rubber cheaper than Wood.
23*s.* 10*d.*	20*s.* 6*d.*	19*s.* 6*d.*	22 ℔ cent.	5 ℔ cent.

Mr. Cowper exhibited and explained a diagram, showing the nature and operation of the joints; and having stated that the cost would not exceed one half of that of the ordinary lead joints, a member enquired, what would be the comparative durability? He was given to understand that lead would endure for 50 years.

Mr. Fothergill apprehended great difficulty in repairing the joints, without disturbing a great number of adjacent pipes.

Mr. Clift had no doubt they would answer extremely well for street mains, or in straight lines; but doubted, with Mr. Fothergill, whether, in the event of an escape of gas, or water, they could be conveniently repaired in angular positions. He conceived that the greater the pressure of water the sounder would the joint be; but the less the pressure the greater the liability to escape.

Mr. Richards spoke to an experience of twelve months of the joints in question. In the month of June he had occasion to re-lay the town of Worcester with new gas mains,—the vibration of the road having induced leakage to a considerable extent. He accordingly applied to Messrs. Mackintosh for some of these joints, and could speak, in confident terms, to the value of the invention. He first applied them, in the works, to ascertain whether they would sustain the effect of the ammonia and corroding gas; and he had also tried them in the street, and in both cases they were entirely unaffected by the components of the gas, and still remained perfectly tight. He had also applied them in the street mains, and they were decidedly tighter than the old joints. With reference to the expense, it was below one half of the old plans, and there was by no means the difficulty in repairing them which seemed, by some, to be anticipated; for he had recently tested it where there was an inclination of 30 degrees, and by removing half a dozen joints, he was enabled to make the repair desired, which could not have been done in the case of the old ones. In fact, he believed them to be superior to anything else in use, and intended to apply them to gas purposes generally.

Mr. Humphreys said it appeared to him to be a very valuable application; and if they left off the bead in the pipes, which

appeared to him perfectly useless, they might incline or angle the pipes to any extent.

Mr. Fothergill agreed with the last speaker, that, on the plan proposed, they could incline the pipes to any extent; and the only point to be guarded against was, the fact, that it would require a length of time to ascertain their durability. They could not tell how the frost, or a change of temperature, would influence them; but, otherwise, as far as he could see, the invention was a very valuable one.

Mr. Richards observed, that he had had some of the pipes exposed to all kinds of temperature, throughout the whole of last winter; and under all extremes of frost, he found they still retained their form and elasticity, and were impervious to the action of all gaseous matter.

The Chairman then remarked, that he presumed, from what had transpired on this subject, that it was the sense of the members that this was a very useful application, and that on all points, excepting that of durability, which time alone could determine, it had their approval. The remarks of the Chairman met with the affirmative response of the members.

The Chairman intimated, that the further consideration of Mr. De'Bergue's collision apparatus, and of Mr. Richmond's engine connecter, must, in the absence of these gentlemen, be postponed.

The Chairman rose to announce, that the Committee of Council appointed to revise and alter the Rules, as authorised by the Annual Meeting in January last, had finished its labours; and a copy of the proposed alterations he held in his hands. The Council had determined, that before asking the sanction of the members to these new Rules, each member should be supplied with a copy,—so that between the present time and the next meeting, they should all be able to form an opinion on them. At the next meeting they would be put to the vote. The existing rules required that the proposed Council and Officers for 1849, should be put in nomination at the present meeting; the Council were, accordingly, prepared with a list of gentlemen whom they begged to nominate,—leaving it to any member of the Institution to add to the number. The following is the list:—

PRESIDENT,
ROBERT STEPHENSON, Esq.

VICE-PRESIDENTS,

Messrs. JOSEPH MILLER,
J. E. M'CONNELL,
CHARLES BEYER,
JOHN PENN,
DAVID ELDER,
JOSEPH WHITWORTH.

COUNCIL,

Messrs. EDWARD HUMPHREYS,
J. SCOTT RUSSELL,
BENJAMIN FOTHERGILL,
R. B. PRESTON,
WILLIAM BUCKLE,
E. A. COWPER,
JAMES FENTON,
THOMAS CABRY,
EDWARD JONES,
W. A. MATTHEWS,
ROBERT SINCLAIR,
ARCHIBALD SLATE,
WILLIAM WEALLENS,
RICHARD PEACOCK,
JOHN RAMSBOTTOM,
WILLIAM HARTREE,
P. R. JACKSON.

TREASURER,
CHARLES GEACH, Esq.

No names having been added, the list was adopted by the meeting.

The Chairman continued—Another matter for the consideration of the meeting was, to receive the announcement of the Council, that their worthy Secretary, Mr. Kintrea, had tendered his resignation. The Council had, therefore, made inquiries, and had agreed to nominate a gentleman whom they considered well qualified to succeed Mr. Kintrea, viz., Mr. W. P. Marshall, lately Locomotive Engineer of the Norfolk Railway. Mr. Kintrea would, at the close of the meeting, supply the members with copies of the lithographs of Mr. Beyer's drawings of the Luggage Engine, "Atlas."

A lengthened conversation ensued as to the high qualifications of the gentleman nominated as Secretary, and also with reference to the interpretation of the rule affecting the election of officers.

Mr. Woodhouse then rose and said, it gave him great pleasure to propose a hearty vote of thanks to Mr. Kintrea, the Secretary, for the very efficient and satisfactory manner in which he had performed the duties of his office, and for his great attention to the interests of the Institution.

The Chairman entirely concurred in the proposed vote; and added, that the Council had already passed a resolution, and entered it on the minutes, expressive of their high sense of Mr. Kintrea's valuable services.

The resolution was seconded by Mr. Buckle, as a member of Council, and passed with acclammation.

Mr. Kintrea briefly returned thanks; and the proceedings terminated.

INSTITUTION

OF

MECHANICAL ENGINEERS.

REPORT OF THE

PROCEEDINGS

AT THE

ANNUAL GENERAL MEETING,

HELD IN BIRMINGHAM, ON 24TH JANUARY, 1849.

J. E. M'CONNELL, ESQ., V.P.,

IN THE CHAIR.

BIRMINGHAM:
BENJAMIN HUNT AND SONS, 75, HIGH STREET.

1849.

PROCEEDINGS.

The Annual General Meeting of the Members was held at the Queen's Hotel, Railway Station, Birmingham, on Wednesday, the 24th of January, 1849; J. E. M'Connell, Esq., V.P., in the Chair.

The minutes of the last General Meeting having been read by the Secretary, were confirmed.

The Chairman rose and said, they were meeting to record their proceedings at the Second Annual Meeting of the Institution of Mechanical Engineers; and it had fallen to his lot to occupy the office of Chairman, in consequence of the absence on the continent of their President elect, Mr. Robert Stephenson, whose absence they very much regretted. In accordance with the rules, the Council had drawn up a report of the proceedings of the last year, which he would proceed to read.

INSTITUTION OF MECHANICAL ENGINEERS.

SECOND ANNUAL GENERAL MEETING, HELD 24TH JANUARY, 1849.

REPORT OF THE COUNCIL.

The Council have great pleasure and satisfaction at this Second Annual Meeting of the Institution, in congratulating the members on the continued and successful progress of the Institution, and the large increase in the number of the members; who have been nearly doubled during the last year, and amount to 189 Members, of whom sixteen are Honorary Members.

This increase in the number of members has been greater than was expected to take place in the time, and shows that the advantage and importance of this Institution are felt and appreciated by the Engineering and Mechanical Profession; it promises

well for the future progress and extension of the Institution, and its efficiency in carrying out the objects for which it was originally founded.

The Council wish to draw the attention of the members to the importance of giving all the assistance in their power to advance these objects and increase the utility of the Institution, by obtaining the addition of new members, and particularly by the communication of papers, with drawings and models, descriptive of new inventions or improvements that have been made by them, or have come under their observation, and the particulars of experiments and trials made with new or old machinery, etc., or the register of the regular working of stationary engines, locomotives, or other machines.

The Council invite communications from all the members and their friends on any engineering subjects that will be useful and interesting to the Institution; and they hope that no members will withhold their communications on account of the want of opportunity to make them so complete and lengthened as they desire; as it is one of the first objects of the Institution to collect and record facts relating to the professional experience of the members, and to procure early and authentic information respecting new mechanical inventions and improvements, for the mutual information and advantage of the members.

Amongst the communications from the members during the last year, the Council have the pleasure of acknowledging in particular the following additions to the Papers of the Institution :—

On A Perforating Machine	by *Mr. Fothergill.*
— Balancing of Wheels in Locomotives.........	*Mr. M'Connell.*
— Rotary Engines	*The President.*
— Boring Cylinders	*Mr. Beyer.*
— Boiler Explosions	*Mr. Smith.*
— A new Boiler and Condenser..................	*Mr. Craddock.*
— An Hydraulic Starting Apparatus............	*Mr. Jackson.*
— An Express Locomotive Engine	*Mr. Samuel.*
— A Railway Carriage Elevator..................	*Mr. Kinmond.*
— A Machine for preparing Bone Manure ...	*Mr. Buckle.*
— The Cambrian Engine	*Mr. Jones.*
A Memoir of the late President.................	*Mr. Scott Russell.*

The Council have to allude, with feelings of the deepest regret, to the recent loss sustained by the Institution in the death of their late President, who will be always remembered by the members with the greatest respect and esteem, not only as a man of exalted genius, but as the first President, and the early and efficient supporter of this Institution.

A careful revision of the Rules and Bye-Laws of the Institution has been made by a Committee appointed for the purpose, in accordance with a resolution of the members; and a revised set of Rules, prepared by this Committee, has been circulated amongst the members, and is submitted to them for approval at the present Annual Meeting.

The Officers of the Institution go out of office this day according to the rules, and a ballot will be taken at the present meeting for the election of the Officers for the ensuing year. In submitting the list of Officers nominated at the last meeting of the Institution, to be elected at the present meeting, the Council congratulate the members on the willingness of Mr. Robert Stephenson to succeed his late lamented father as the President of this Institution. They also consider it fortunate that they have been able to prevail upon Mr. Marshall to accept the office of Secretary, vacant by the resignation of Mr. Kintrea; if it shall be the pleasure of this meeting to appoint him to that office, the duties of which he has been performing pro tem.

The following Report has been made by the Finance Committee, containing the Financial Statement of the affairs of the Institution for the year ending 31st December, 1848.

REPORT OF THE FINANCE COMMITTEE,

To the Council of the Institution of Mechanical Engineers, Jan. 19, 1849.

Your Committee having carefully examined and checked the various receipts and payments of the Institution during the year ending the 31st December, 1848, beg to report that the enclosed Balance Sheet rendered by the Treasurer is correct.

Since the 31st December, the account has been paid for the engravings of the Atlas Luggage Engine and the Multifarious

Perforating Machine, that have been supplied to the members; leaving an available balance now in hand of £147. 9*s*. 1*d*. There are several copies of these engravings remaining in the possession of the Institution, which are intended to be supplied to the members at a moderate price, and for the purpose of affording an opportunity to the future members, and members' friends, of obtaining copies of these very excellent and valuable engravings.

(Signed) ARCHIBALD SLATE.
E. A. COWPER.
WM. BUCKLE.

INSTITUTION OF MECHANICAL ENGINEERS.

BALANCE SHEET,

For the Year ending 31*st December*, 1848.

Dr.	£.	s.	d.	*Cr.*	£.	s.	d.
To Subscriptions from 3 old Members, being arrears for 1847	15	0	0	By Advertising, Stationery, and Printing	87	18	7
— Subscriptions from 52 old Members for the year 1848	156	0	0	— Petty Disbursements and Office Expenses	23	7	2
— Subscriptions from 110 new Members for the year 1848	550	0	0	— Office Furniture	22	16	6
— Donation from J. MacGregor, Esq.	20	0	0	— Postages	27	8	9
— Balance from 31st Dec., 1847	218	6	5	— Travelling Expenses	23	11	4
				— Rent of Office	45	0	0
				— Salaries	300	0	0
				— Subscription paid in excess	5	0	0
				— Balance	424	4	1
	£959	6	5		£959	6	5

(Signed) ARCHIBALD SLATE.
E. A. COWPER.
WM. BUCKLE.

19*th January*, 1849.

The CHAIRMAN observed, that the Council, in retiring from office, all agreed that the advantages had not yet been fully reaped which an Institution of this description was calculated to bestow on its members. The last year had been a particularly unfortunate one as respects the officers of the Institution; they had lost their late respected President, and there had necessarily been some want of active management caused by the change of officers, which,

together with the depression of the times, had rendered the efficiency of the Institution less perceptible than it would otherwise have been. They now, however, saw the elements of success strongly marked; and, as the report recommended, it rested with the Members themselves to carry out the objects of the Institution, and to make it, as it deserved and was intended to be, the first institution for the class of subjects for which it was founded. He regretted very much that they had not had at that meeting the presence of their President elect, Mr. Robert Stephenson, a gentleman whom they all respected, and who, he was sure, would do all in his power to extend the benefits of this Institution and promote its best interests. He hoped that at their next quarterly meeting they should have the pleasure of meeting Mr. Robert Stephenson, who would then be able to impress on them, with more power than he was capable of, the advantages which this Institution will afford to the members, and which he had no doubt will be obtained by proper attention to the object for which it was founded, (applause).

Mr. Ramsbottom said, he had great pleasure in moving the adoption of the Report that had just been read.

Mr. Whitworth seconded the motion, and it was passed.

The Chairman said, the next subject for their consideration was the appointment of the President for the year ensuing. Mr. Robert Stephenson was proposed at the last meeting; but in order to comply with the rules of the Institution, it was necessary that he should be formally elected by the members at the Annual Meeting. He felt sure it was quite unnecessary for him to say one word in support of that proposition, as Mr. Robert Stephenson was a gentleman so well known, and his character and talents were so universally acknowledged; he therefore begged leave to propose him as President of the Institution of Mechanical Engineers.

Mr. Fothergill said, he had very great pleasure in seconding that nomination, and the resolution was passed with acclamation.

The Chairman said, the other appointments of Treasurer and Secretary were now to be filled up for the ensuing year.

Mr. Thornton (Mayor of Birmingham) said, he rose with

great pleasure to propose a vote of thanks to the respected Treasurer of their Institution for the past year, Mr. Charles Geach, and he begged to propose that he be elected Treasurer for the ensuing year. He very much regretted that indisposition prevented Mr. Geach from being amongst them on the present occasion; the more especially as he was prevented by a similar cause from being present at the last Annual Meeting. Since then he had been amongst them, but to the extraordinary manner in which he had performed the duties of his recent office of Mayor might be attributed, in some measure, his present indisposition. They would recollect the great interest which he took and the attention he bestowed in the formation of this very valuable Institution; and the interest he takes in attending the meetings must render it a source of great regret to the members that he was not able to be present at that meeting.

The resolution was seconded by Mr. Buckle, and carried.

Mr. Henderson proposed that Mr. Marshall be appointed Secretary for the ensuing year; he said the members so well understood the qualifications of Mr. Marshall for that office, that in his presence he thought it quite unnecessary to make any remarks on the subject; he most cordially proposed his appointment.

Mr. Peacock said he had great pleasure in seconding the appointment of Mr. Marshall to that office, and the resolution was passed.

The Chairman said the next subject to be considered was the Rules. The members would recollect, that at the last annual meeting, a Committee was appointed for the purpose of making certain amendments considered necessary in the rules. That Committee had drawn up an amended code of rules, of which a copy had been sent to all the members for their consideration, and it was the duty of that meeting to decide upon these rules. He moved that these rules, as submitted to the members, be now adopted as the Rules of the Institution.

Mr. Slate seconded the motion, and said, that as one of the Committee engaged in re-modelling these rules, he felt that their best attention had been given to them; and the resolution was passed.

The CHAIRMAN said, the Committee appointed to open the ballot lists, reported that the following members were elected as the Vice-Presidents and Council for the ensuing year.

VICE-PRESIDENTS.

Mr. CHARLES BEYER, Manchester,
Mr. J. E. M'CONNELL, Wolverton,
Mr. JOSEPH MILLER, London.

COUNCIL.

Mr. WILLIAM BUCKLE, Birmingham,
Mr. THOMAS CABRY, York,
Mr. E. A. COWPER, Birmingham,
Mr. JAMES FENTON, Leeds,
Mr. BENJAMIN FOTHERGILL, Manchester,
Mr. EDWARD HUMPHREYS, London,
Mr. EDWARD JONES, Bridgewater,
Mr. W. A. MATTHEWS, Sheffield,
Mr. RICHARD PEACOCK, Manchester,
Mr. R. B. PRESTON, Liverpool,
Mr. JOHN RAMSBOTTOM, Manchester,
Mr. J. SCOTT RUSSELL, London,
Mr. ROBERT SINCLAIR, Glasgow,
Mr. ARCHIBALD SLATE, Dudley,
Mr. WILLIAM WEALLENS, Newcastle-on-Tyne.

The Chairman announced that the following new Members were also elected.

MEMBERS.

Mr. CHARLES COWPER, London,
Mr. WILLIAM FAIRBAIRN, Jun., Manchester,
Mr. JOHN JAMES RUSSELL, Wednesbury,
Mr. JOHN TAYLOR, Manchester,
Mr. J. B. TIERNEY, Tipton.

HONORARY MEMBER.

Mr. EATON HODGKINSON, London.

Mr. FOTHERGILL said, he begged leave to intimate that it was his intention to retire from the Council, as he felt a disposition to make way for some one else, who would do his best to promote the interests of the Institution.

Mr. CLIFT said he had great pleasure in proposing a vote of thanks to the Council for their valuable services during the

past year. Owing to their great zeal and diligence, notwithstanding the hindrances that might have resulted from the lamented death of the President, everything had been done for promoting the best interests of the Institution.

The motion was seconded by Mr. HENRY SMITH, and passed.

The CHAIRMAN said, he had been requested by the Council to return thanks for the kind vote of confidence and approbation with which they had been favoured. He could say on behalf of himself and the other members of Council, that the time they had devoted to the interests of the Institution was a serious consideration to many of them, and as one of the early supporters and friends of the Institution, he could speak feelingly on that point; but though, with respect to those interests, they had laboured heartily and earnestly, they would be fully rewarded when they found the Institution take that position in the scientific world to which they considered it entitled, as the Institution of Practical Mechanical Engineers, (applause). He had now to bring before the Meeting some Papers, which had been supplied to the Council and approved for their consideration.

The SECRETARY then read the following paper by Mr. De Bergue, who pointed out the references on the drawing.

ON A STATION BUFFER.

AAAA represent the timbers forming the framework of the apparatus, BB being the main posts against which the pedestals of the cross shaft, or axle, are fastened.

C is a wrought-iron Shaft supported on a journal at each end; there are two Pinions DD on this Shaft, which are of wrought-iron, and cut out of the solid shaft; the centre of this shaft has a boss, a little larger in diameter than the outside diameter of the pinions, and upon this boss there is a cast-iron Friction Pulley, which is firmly keyed to it; the outside of this pulley is turned, and is surrounded by a friction clip EE.

The moveable Buffer rods FF are made of timber, and are furnished at the under part with two wrought-iron Racks, which are firmly bolted to them; these racks gear into the two pinions on the main axle; the pitch of the teeth is 1½ inch, the breadth of the racks 5 inches, and the breadth of the pinions 5½ inches. Above the pinions and above the wooden buffer rods, two friction pulleys GG are placed to keep the racks properly in gear.

HH are two cast-iron Cheeks, resting at one end on the shaft, the other ends being firmly bolted to the ground; these cheeks are placed on each side of the friction pulley, the shaft revolving freely through them, but they act as levers to resist the revolving power of the shaft when it is set in motion; these cheeks are connected together at I by a strong cylindrical stay bolt, which passes through them both, and to this bolt I one end of the friction clip E is attached. JJ are two smaller cheeks, also held in their position by the bolt I, upon which they revolve freely. The other end of the friction clip E is attached, by means of a round bolt or stay K, to the lower extremities of these two smaller cheeks, as shown in the section.

L is a steel Spring, attached at one end to the two small cheeks, and pressing at the other end on the back of the wrought-iron curved Lever M; this lever is held at one end by the aforesaid bolt I, which passes freely through it, and upon which it can oscillate. NN is a cross beam made of angle-iron; this beam is fastened at the ends to the two buffer rods, and travels with them: on the centre of this beam, and just under the lever M, there is a small friction roller P, with a groove in it, in which groove the under and curved part of the lever M rests.

Now when the Buffers are driven up by the impetus of a body coming in contact with them, it is evident that the Racks, gearing into the Pinions on the shaft, will compel the Shaft and the Friction Pulley to revolve in the direction of the arrow, and that the friction clip will offer a resistance to the revolving of the friction pulley in proportion to the pressure or strain put upon it by the pressure of the Spring L, and this pressure may be regulated at will by means of the set screw O; but as the buffers proceed in their course, the grooved Roller P is carried forward in a horizontal straight line, and thus forces up the curved Lever M, which pressing harder on the end of the Spring L, keeps increasing the pressure on the friction clip, and in consequence the resistance of the Buffing apparatus.

The advantages of this Buffer are, that it is simple and most effective in its results, as it may be regulated to act with any desired amount of resistance; it occupies but little space, is not expensive, and has no recoil action.

The CHAIRMAN asked Mr. De Bergue if he could state the expense of one of these buffers fixed at a station.

Mr. DE BERGUE said he did not know exactly, but thought it would be about £120.

Mr. SLATE asked him to explain his view of the superiority of this buffer over the ordinary spring buffers.

Mr. DE BERGUE said, that in the ordinary buffers, the springs have to move through a great space, presenting very little resistance at first, and it was only when they were driven up considerably that they gave out their resistance; but when a train was stopped there was a certain quantity of momentum to be overcome at once. In his plan there was the advantage of the buffer being regulated to traverse as much as was required, and the amount of resistance regulated throughout; and then again there was no recoil of the buffer. A spring buffer could not be regulated in that manner, and there was the recoil of the springs to contend with.

Mr. ADAMS asked whether any member could give information about the Hunt's-Bank Station Buffer.

A MEMBER said, he believed it was made with a series of 4 double springs, and had about 6 feet length of action, and that it had no recoil.

The CHAIRMAN asked Mr. De Bergue what was the range of his buffer.

Mr. DE BERGUE said, the one shown in the drawing had a range of 8 feet, but he was making one like it for Mr. Fowler with 3 feet range.

The CHAIRMAN asked what range he would recommend.

Mr. DE BERGUE said, that must depend very much on the station; if it were an inclined plane, it would of course require a much more powerful one: he would propose 6 or 8 feet range for such a station as Birmingham. A spring buffer had no recoil when made with racks to hold back the springs when they were driven up; but if the catches of the racks gave way, there would be injury from the recoil. In his plan there was no recoil; the buffer was worked back by hand after it had been driven up.

The CHAIRMAN observed, that the advantage of the buffer appeared to consist in the ease with which it could be brought back to its former position without any recoil.

Mr. FOTHERGILL said, it appeared that the difference between the invention of Mr. De Bergue as represented there, and other plans in operation, consisted in the fact that in his plan it is

done by friction but in others it is accomplished by a series of springs, and the recoil of the springs produces re-action, whereas in his plan there is no recoil of the buffer. In proportion as the set screw was put on or taken off, the amount of friction given out was increased or decreased; and according to the weight of the trains or the position in which the buffer might be placed, so it appeared the buffer might be regulated in different instances, to the amount of momentum to be overcome.

Mr. PEACOCK remarked, that one objection struck him, that the whole of the resistance had to pass through the shaft between the drum and the pinion, and he thought that a sufficient friction might be put on to cause the shaft to twist and break instead of revolving. That might be overcome by having two drums, one close to each pinion, thus reducing the length of the shaft; but when that was done it would not, he conceived, possess any advantage over the ordinary elliptic-spring buffer already spoken of as applied at Manchester. From what he had heard, he thought that one was a very simple and effectual one, and it was provided with sufficient catches to hold any amount of strain that might be placed on the springs; he thought the catch was so simple a matter that it ought scarcely to be called an objection, a simple spring would keep down the catch, or it might be kept down by a weight. There was a mode of bringing back the buffers very similar in description to Mr. De Bergue's plan; it was effected by a cross shaft and a wheel with gearing introduced between the buffers, so as to take off the strain of the springs from the catches; the catches were then lifted up, and the buffer worked back by hand. He thought that was quite as effectual in its action as Mr. De Bergue's buffer; but his impression was that the latter would not stand so severe a blow as a spring buffer, and even if it would, he thought the other would be preferable on the ground of expense, for he thought the elliptic-spring buffer would be less expensive.

Mr. DE BERGUE said, that a much greater resisting power could be obtained by his plan than by any spring buffer. If a force of 100 tons moving through 10 feet of space was to be overcome, it could not be overcome with the ordinary springs,

there were none made strong enough; but with his principle of friction it might be done. The most powerful spring buffers would not overcome more than 4 or 5 or 6 tons, but he proposed to begin with 3 or 4 tons, and to go on increasing it to 10 tons, or as much as the train of carriages could stand.

Mr. HODGE asked what he proposed to make the rack of.

Mr. DE BERGUE said, wrought iron, cut out of the solid.

Mr. HODGE asked if he did not think that with the percussive force of a train, proceeding at the rate of 10 or 12 miles an hour, the teeth would be stripped.

Mr. DE BERGUE did not think so, because it would be useless to put a strain on the friction drum sufficient to strip the teeth. A train running at 12 miles an hour could not be stopped in 8 feet.

Mr. HODGE observed, that he was doubtful of the resisting power of the teeth, on account of the sudden percussive force they would be subjected to; but he thought there was great range in the buffer, and approved of its principle more than of the spring buffer.

Mr. DE BERGUE said, that he calculated each tooth of the rack would stand a force of 20 tons.

The CHAIRMAN asked him to give the result of the trial of the buffer he was making for Mr. Fowler, when it was completed.

The CHAIRMAN then called upon Mr. Richmond to explain his Improved Engine Counter, which was exhibited to the meeting.

DESCRIPTION OF AN IMPROVED ENGINE COUNTER.

This Engine Counter is not brought forward as an original invention, but as an improvement on the engine counters previously used. The main points of improvement are the simplicity and certainty of the action; for however rapidly the Counter may be worked, it is impossible that the first, or units hand, can move more or less than one division of the dial for each stroke of the engine; and another improvement is the method of calculation adopted, all the hands revolving the same way. This Counter is much less expensive than those previously used, and it is now being generally adopted for marine engines going transatlantic voyages; the expense of the Great Western Counter was £25

or £35, whereas the price of this instrument is only £7, and it tells up to 1,000,000. Another point of importance is the great expense in the Great Western and Great Britain steam ships of attaching the engine counter to the main shaft, whereas all that is required with this Counter is a reciprocating action of half an inch. There is also a security against mistakes in reading off the counter, each dial keeping a check on the other. When No. 1 has reached 100, No. 2 will have marked one division; when No. 2 has reached 1000, No. 3 will have marked one division; and when No. 3 has reached 10,000, No. 4 will have marked one division, so that it is impossible that any mistake can occur in the end, as each dial continually checks the next one.

The CHAIRMAN asked Mr. Richmond if he could give any information respecting their actual employment in any case.

Mr. RICHMOND said, one of them had been in use at the Chelsea Water Works for the last twelve months, and Mr. Simpson had stated that it had performed in the most satisfactory manner, and was superior to any other description of counter that he had tried.

The CHAIRMAN asked if he could make one on that plan that would register the miles run by a locomotive engine, and that would not be injured by the ordinary jerking at a high rate of travelling, collisions of course excepted; and what would be the expense.

Mr. RICHMOND said he could make such a counter, but he wanted to know the number of revolutions that would be required before he could tell the expense. A counter registering 1,000,000 revolutions cost £7, but one registering 10,000,000 would be £8, because another dial would have to be introduced.

Mr. SLATE remarked, that the principal point appeared to consist in the form of the escapement, affording a principle for registering higher velocities. In other respects it was as old as he could remember, and he did not see anything new in it, but if it would register the revolutions of a locomotive, it would do more than any one had been able to accomplish before.

Mr. RAMSBOTTOM said, he was now applying an engine counter to a locomotive, but the difficulty he experienced was in the great number of revolutions which a wheel makes in a given time; it was evident that the motion cannot be given from the

driving wheels because of the slipping, and the other wheels make as many as 480 revolutions in a minute. There was therefore this great objection to it; but he proposed to derive the first motion from a worm on the axle of the wheels, with a vertical shaft to the counting apparatus, and attaching that to the ordinary gas meter dials, which he thought was quite sufficient.

Mr. RICHMOND observed, the hands of the gas meter dials did not revolve all the same way, as was the case in his counter, and that was an advantage in the latter.

The CHAIRMAN suggested that it might be worth his attention to see whether he could devise some plan for applying it to the purpose mentioned, as it was very desirable to have a counter for the number of miles run by a locomotive.

Mr. RICHMOND said, in answer to a question, that he had tried very great speed on his counters, but not so much as 400 strokes per minute.

Mr. FOTHERGILL said, in connection with this counter he would mention the counting apparatus generally used in cotton spinning machinery, which registers up to 4,000 in one revolution of the two discs; it is placed on a wheel which receives its motion from a pinion, and he had no doubt it would suit the purposes of Mr. Ramsbottom, and it would not be so bulky as this counter by one half.

The CHAIRMAN asked Mr. Whitworth if he had not some plan of counter.

Mr. WHITWORTH said it was very simple, it was a worm working in two wheels, and counted up as high as 30,000.

The SECRETARY then read the following paper by Mr. Hick, of Bolton.

ON A PATENT STARTING AND DISENGAGING APPARATUS.

This Apparatus is used for connecting and disconnecting steam engines or other motive power, with shafts and machinery, in such manner as to gradually transmit or withdraw the power required for driving the machinery, and modify the intensity of the shock caused by sudden connection or disconnection.

In cotton mills, where this apparatus has been applied to the lines

of shafting in each room, either to the driving wheels or to the first coupling, its utility and advantages have been fully developed; it gives the means of instantaneous disconnection from the main driving shafts, which can be effected by a child, and in many instances its adoption would ameliorate if not prevent the frightful accidents which are so often occurring, and which are often aggravated by the want of such means, and the loss of time which takes place in communicating with the engineer, and stopping the whole of the engines and machinery.

This apparatus is also peculiarly well adapted for bleachers, mangles, calenders, squeezers, and dash-wheels, and is now extensively in use.

It may be applied advantageously to almost any machine, or in any situation in which the common catch box and friction straps are or can be used, and also may be applied to spur, bevel, or mitre wheels, or couplings of shafts, and can be made of any power or magnitude.

The accompanying drawing shows five different modifications of the apparatus, and these may be extended to suit peculiar situations.

Figures 1, 2, and 3 represent the Apparatus as applied to a pair of Bevel or Mitre Wheels; and this is equally applicable to spur wheels, or couplings of shafts. Upon the driving Shaft A the Wheel B is keyed, that works into the Wheel C, which is prepared with a projection D, and a pair of ordinary Friction straps E, and runs loose upon the cross Shaft F that has to be put in motion.

The two Screws G G, with right and left-handed threads, and having a toothed Pinion H H upon the middle of each, work between the two jaws cast upon the driving Arms J, which arms are keyed upon the shaft F, and fitted with two toothed Quadrants K K, gearing into two toothed Racks L L, at the nearest point to the centre of the Shaft; one end of these racks is secured to a Ring M, which slides on suitable keys in the shaft F, and the Racks, &c., are carried round with the Shaft.

The sliding Ring M is moved by Levers in the usual way as applied to the common catch box. When the Shaft F, the driving Arm J, and the toothed Quadrants, Pinions, Friction straps, &c., attached, are stationary, the Wheels B and C, and Shaft A, only are in motion, and the Ring M will project out the length of the Rack, as shewn in the drawing. By forcing up this sliding Ring and Racks with the Levers, motion is communicated by the Quadrants to the Pinions, and right and left-hand Screws; which tightens the Friction strap, and gently and gradually gives motion to the Shaft A, and any machinery driven by it.

This plan may be adopted or introduced into ordinary gearing now

at work, with very slight alterations in their present arrangement of ordinary catch boxes.

Figure 1 is a Sectional Plan.

Figure 2 is a Sectional Elevation.

Figure 3 is an End Elevation.

Figures 4, 5, and 6 represent the Apparatus as applied to a pair of Bevel Wheels in an *internal form*, and this may be also applied to any other sort of Wheel or Coupling. A is the driving Shaft, upon which the Wheel B is fixed, working into the Wheel C, which is prepared with a projecting Ring D, and runs loose upon the Shaft F; inside the projecting Ring D is a driving Disc G, fitted and keyed upon the Shaft F, and this Disc is fitted with three expanding Segments H H H, lined with sheet copper, or other metal, to prevent the interior of the Ring D from galling, which copper, &c., may be replaced when worn. The expanding Segments H H H are secured to the Disc G at the centre of each by three projecting Driving pieces J J J, fitted and sliding freely in corresponding grooves in the Disc G, and each Segment has also two bolts K K, with nuts screwed against shoulders, and fitting slotted holes to admit of expanding, yet keeping the Segments H H H close to the Disc G. Also between the ends of each Segment there are three Screws L L L, with right and left-handed threads, fitted into suitable adjusting nuts, and from the middle of each screw a Lever M projects towards the centre of the Shaft F; each Lever is connected by a Link and pin to a Ring N, which slides upon suitable keys in the shaft F, and is carried round with it when in motion.

The sliding Ring is moved in and out by Levers in the usual way.

When the Shaft F and the driving Disc G, with its expanding Segments H H H, Screws, Levers, Links, and sliding Ring, attached thereto, are stationary, the Wheels only and the Shaft A are in motion, and the Ring D, with its Links, &c., will project out as far as the Levers and Links permit. By forcing up the Ring, motion is given to the right and left-handed Screws, which expand the Segments pressing their outer surface (which is covered with sheet copper, or other material) against the interior of the projecting Ring D with a gentle and gradual force, equivalent to the power required.

Figure 4 is a Sectional Plan.

Figure 5 is a Side Elevation.

Figure 6 is an End View.

Figures 7, 8, and 9 represent the Apparatus upon a very simple

plan of construction, which may be applied to Spur, Bevel, and Mitre Wheels, or Couplings for Shafts.

A is the driving Shaft, B a Spur Wheel keyed upon it, working into the Spur Wheel C, which is prepared on one side with a projecting Ring D, and runs loose upon the Shaft F, which is connected with the machinery to be driven. Upon this Shaft is keyed a driving Disc G, into the periphery of which, on opposite sides, two or more brass Slides H H are fitted into suitable grooves, and the outer surfaces of them are fitted to the interior of the Ring D, and extend about one-eighth of its internal circumference. Between these Brass Slides and the centre boss of the Disç G, are fitted two or four Screws J J, with adjusting nuts, and with a projecting Arm K K forged to the end of each Screw nearest the centre of the Shaft, but projecting outwards. A Ring M sliding on keys in the Shaft F (and carried round with it when in motion) is connected by Links and pins to the projecting part of the Screws J J, and is moved in and out by Levers in the usual way; giving motion to the Screws which press out the brass Slides or driving pieces H H, against the interior surface of the Ring cast on the driving wheel, and give the means of gentle and gradual motion to the machinery.

Figure 7 is an Elevation.
Figure 8 is a Sectional View.
Figure 9 is an End View.

Figures 10, 11, 12, and 13 represent the Apparatus applied in the form of a disengaging Coupling for a Shaft, and the same modification may be applied to Wheels, &c.

A is the driving Shaft; B a hollow Box or Disc, forming the exterior of the coupling and keyed upon the Shaft-end, its centre boss extending over the end of the Shaft A; into this a brass bush is fitted, and also the end of the driven Shaft C, which revolves freely therein. Upon the exterior of the centre boss belonging to the Disc B, are fitted two expanding Segments D D, with their external surface lined with sheet copper, and fitted against the internal surface of the outer Disc B. The Ring E slides upon suitable keys in the Shaft C, and is fitted with two hardened taper projecting Arms F F introduced between the Segments D D at opposite points, and fitted against adjusting screws.

The sliding Ring E, with its projecting Arms, is moved in and out by levers in the usual way.

When the Shaft C and sliding Ring E, with its projecting Arms and Segments, are stationary, only the driving Shaft A and the outer Disc B are

in motion, and the Ring E will project from the coupling about the length of the projecting Arms, but retains its hold of the Segments; by forcing the Ring E by the Levers as before mentioned, the segments expand against the interior surface of the outer Disc, and put in motion gradually the shafting and machinery required to be driven.

Figure 10 is a Sectional View through the centre of the Shafts.

Figure 11 is an Outside View.

Figure 12 is a Front View, with the sliding Ring removed.

Figure 13 is a Detached View of the sliding Ring.

Figures 14, 15, 16, and 17 represent the Apparatus in somewhat similar form to the one last described, but modified so as to be applied to a pair of Bevil Wheels; the principal difference relating to the expanding Segment, which is made in three parts, and having three corresponding tapering projecting Arms attached to the Sliding Ring.

The CHAIRMAN remarked, that in future papers it would be desirable to have the drawings on a larger scale, and the parts well defined, so that the members in the distant parts of the room might clearly understand them; and he hoped that this suggestion would be adopted by those members who might be preparing papers.

Mr. COWPER said, this starting apparatus appeared to be on the same plan as one used by Mr. Oldham, of the Bank of England. In the simplest form of the apparatus shown on the drawing, there were 3 segments made to fit into a box, and they were forced into contact with the box by a toggle joint moved by a lever; in the next form shown the segments were forced out by a screw, and in the other by a wedge. It was very like the expanding mandril, and he thought it the best kind of clutch ever made, and very easily managed.

Mr. BUCKLE said, it was the best contrivance of the kind that he knew. They had a number at Soho, very similar in construction, from 12 to 36 inches in diameter, and they both engaged and disengaged without the least noise or concussion. He had used them with 4, 3, and 2 segments, and found that those with 2 segments answered as well as the others; they had been used at Soho for 18 or 20 years. He had many objections to the cap and screw clutch, and the crab and cone clutch, as they made a

great noise and concussion, and risked the breaking of the shafts. These objections led him to try the radial clutch with 3 segments, which answered the purpose in a satisfactory manner. He had since fitted clutches with 4 and 2 segments with equal success; those with 2 segments appeared to transmit the power as smoothly as the others with more segments. The radial clutch was, in his opinion, the best description of clutch that had been tried.

Mr. HODGE suggested that an engraving of these clutches would be very useful to the junior members of the Institution, and a valuable collection might be made of the various plans that had been invented for the purpose.

The CHAIRMAN observed, that there was now an opportunity for the junior members of the profession to be admitted into the Institution as graduates.

Mr. SLATE asked what was the patent claim in Mr. Hick's clutch.

Mr. FOTHERGILL said, he believed it was the application of this clutch in connexion with something else in calender dash wheels, and such kind of works, that constituted the patent claim.

The CHAIRMAN remarked, that there appeared to be no difference of opinion as to the merits of the clutch, independent of the question of originality.

The CHAIRMAN said, the next subject was a new improvement in Railway Chairs and Switches, invented by Mr. Baines of Norwich, which the Secretary would explain in the absence of the inventor.

DESCRIPTION OF BAINES' RAILWAY CHAIRS AND SWITCHES.

The first portion of this invention is an improved Joint Chair, the object of which is to prevent the joints from rising or getting out of line, and the rails from driving forward. The outer jaw of the chair, as shown in the accompanying specimen, fits close up to the under side of the head of the rails, but the inner jaw is only of sufficient height to clip the bottom flanch of the rail; and the rail is not fixed by a key, but by a square wrought-iron dowel-pin, which is passed through a hole in the outer jaw of the chair, and a corresponding notch in the end of each rail. This dowel-pin is 1¾ inch wide and ⅞ inch thick, and has a large flat

head, and under the head is placed a wrought-iron plate, 9 inches long, which fits close up to the head of the rails on the inner side, and rests on the chair. A square cotter is then driven vertically through the outer end of the dowel-pin, which draws the whole firmly up to the outer jaw of the chair; the wrought-iron plate is ⅜ inch thick in the middle, tapered to the ends, and slightly cambered, and it is sprung flat by driving the cotter. This cotter is made long enough to drive through the bottom of the chair into the sleeper, and serve as the spike on the outer side of the chair; a slot is made in the upper part of it to allow of the cotter being drawn out when required, by inserting a lever in this slot. Two ordinary spikes are driven on the inner side of the chair.

The notches in the rail ends are made by a revolving cutter, which is shown in the accompanying drawing; the rail is laid in a cast-iron bed in the machine, and the cutter is made to a fixed guage, so that all the notches in the rail ends correspond exactly in size and position, and there is no difficulty in keying up the dowel-pin. This is made to fill the hole in the outer jaw of the chair, but only fits the bottom and one end of the notch in the rails, to prevent any weight coming on to it; and it does not interfere with the ordinary allowance for expansion between the rails. The cutting machine is in a portable form to be worked by hand, and the notches in the rail ends can be readily and quickly cut on the ground, with the same accuracy as those made in the manufacture of the rails.

The pressure of the wheels has no tendency to loosen the fixing of the rails in this chair, as it is all resisted by the chair, the outer jaw of which fits close to the head of the rails, and the bottom flanch of the rails is firmly clipped by the inner jaw of the chair. The dowel-pin does not receive any of the pressure of the wheels, but holds the rails firmly against the outer jaw of the chair, and prevents any risk of a foul joint occurring.

The dowel-pin also prevents the rails from rising at the joint, and from driving forwards; and the latter is an important advantage both for safety and economy, as the action of the trains running is continually driving the rails forward to so great an extent as to cause a considerable item in the expense of keeping the line in repair, to prevent the rail ends being driven out of the joint chairs, which would cause a serious accident. In the ordinary construction there is nothing but the friction of the wood keys to resist the driving of the rails; and the effect of the weather on the wood keys, alternately shrinking and swelling them, causes their hold on the rails to be gradually weakened.

The long plate under the head of the dowel-pin fits close up to the head of the rails, and being drawn up tight against them, serves as a scarfing piece to connect the two rail ends stiffly together and prevent the working of the joint. This effect is shown in the two accompanying models of five lengths of rail connected together by these improved joint chairs, and five corresponding rails connected by the ordinary chairs with wooden keys; the first is stiffly coupled together like one piece of rail, but the other is weak and loose at the joints.

The stiffness of the joint causes one rail end to support the other, and prevents the working of the joint and the canting of the joint sleeper during the passage of every train; which is so serious an evil in the ordinary construction of permanent way, causing a shock at every joint from each wheel that passes over it, which weakens the tenacity of the iron, and makes the rails break at a short distance beyond the joint. This increases the smoothness of the road for travelling, as well as the safety, and diminishes the expense of maintenance of the permanent way. The elasticity of the long plate allows of the joint being sprung, as much as is required for slewing the road in laying or repairing.

The next portion of this invention is an improved Intermediate Chair, the object of which is to fix the rail without the use of any key. The two jaws of the chair are made exactly alike, and are set obliquely instead of opposite to each other, as shown by the accompanying specimen and drawing. The chair is slipped endwise on the rail, and then twisted at right angles to the rail, which makes it grip the rail between the two oblique jaws; and the chair is forced tight against the rail on each side and made to hold it firmly by means of the spikes. These are screws with long conical heads, and the holes in the chair are made with an irregular countersink, which is oval and eccentric at the bottom; so that when the spike is screwed into the sleeper close to one side of the hole in the chair, and the conical head is drawn home into the countersink, the chair is forced gradually round and increases the pressure of the jaws on the rail. These holes for the spike heads are made with $\frac{1}{4}$ inch draught, and the oblique position of the jaws, as shown by the accompanying drawing, gives a leverage of three to one to increase the pressure on the rail. The jaws of the chair fit close up to the head of the rail, so as to hold it very steady and firm; but the yielding of the spikes in the wood sleeper allows some elasticity to prevent the road being too rigid. To ensure these chairs being all made correctly to fit the rail, it is proposed to cast them from a metal pattern, a specimen of which is exhibited with the chair.

This chair prevents the rail working loose, as there is no wood key to get slack or lost out, and the spikes are screwed into the sleeper; also the constant serious expense of renewing the keys is avoided, and the expense caused by the great number of chairs broken in driving the keys; which will form an important improvement in economy and safety.

The only trial yet made of these improved Joint and Intermediate Chairs has been at Norwich Station, where a short length in the main line has been laid with them for a few months, which has proved quite satisfactory.

The last part of the present invention is an improvement in Switches, which consists principally in making the tongue of the switch about an inch deeper than the main rail, so that the bottom flanch of the tongue works under the main rail. The bottom flanch is kept entire to the end of the tongue without being cut, which adds materially to the stiffness and steadiness of the switch tongue, by giving it a broader base to slide upon. Another object of this construction is to make the switch clean itself in working, by driving the dirt under the main rail, instead of against it, as in the old construction, where the tongue and the main rail being of the same depth, the dirt gets pressed between them whenever the switch is worked and cannot escape, which is a great source of accident, by preventing the tongue from shutting close and causing it to catch the flanch of the wheels. This is further provided for by the form of the seats of the switch chairs, which are made with a raised face in a diagonal direction for the tongue to slide upon, and sloped off on all sides, by means of which the working of the tongue continually clears the dirt off the face of the chairs.

This switch is capable of being laid either right or left-handed, without giving up the advantage of having the long tongue to lead, because the two tongues are shaped exactly the same on both sides as the bottom flanch is not cut, and they will fit on either side; the only difference in changing from right-handed to left-handed being, that a slight bend of the tongue is required, which is done by the plate-layer in laying the switch. The point of the tongue is prevented from rising when a train passes over, by the bottom flanch of the tongue locking itself under the main rail.

The lever box shown in the accompanying model of the switch, is made to prevent the entrance of dirt, which accumulates in the present boxes on account of the large opening left in the cover for the lever to work through. In this improved lever box, the lever and connecting

rod are both attached at the side of the box to the end of a shaft which passes through a hole in the side of the box, and is connected to the weight inside by a segment; a cover fits closely over the top, so that no dirt can get into the box, as the shaft fills the hole in the side.

The connecting rod between the switch tongues is split at the ends with a notch at each side, and the end of the rod is nipped close to put it through the hole in the tongue, and then springs open and holds the tongue firmly by the notch at each side; the split end is kept open by a vertical split-cotter, and this construction is less liable to get disconnected by accident than the usual connecting rods with screwed ends.

The SECRETARY said, in answer to questions from the members, that this invention was a patent, and the inventor, Mr. Baines, was a practical man of considerable experience and ingenuity, who had been foreman of permanent way on the Norfolk Railway. He was not able, at present, to state the comparative expense, as it was a recent invention, and the switch had not yet been tried. The inventor had mentioned that in the model exhibited of the switch, he had shown the point of the tongue made according to Mr. Wild's patent, dropping under the head of the main rail instead of being notched into it, as he considered that was the best form for the point.

Mr. HODGE remarked that the invention gave evidence of great ingenuity; and, though simple, he thought it comprised several points of great importance.

The CHAIRMAN said it was an important subject to railways generally, and this invention might require some explanation from the maker; he thought, therefore, that the consideration of it had better be adjourned to the next meeting, more especially as there were so many points involved in it that they could not give an opinion upon off-hand. He proposed a vote of thanks to the inventor for his communication, with a request for further information on the subject. This was agreed to, and the proceedings terminated.

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INSTITUTION

OF

MECHANICAL ENGINEERS.

REPORT OF THE

PROCEEDINGS

AT THE

GENERAL MEETING,

HELD IN BIRMINGHAM, ON 25TH APRIL, 1849.

ROBERT STEPHENSON, ESQ., PRESIDENT,

IN THE CHAIR.

PUBLISHED BY THE INSTITUTION.

PROCEEDINGS.

25 April 1849.

The usual General Meeting of the Members was held in the Theatre of the Philosophical Institution, Cannon Street, Birmingham, on Wednesday, the 25th April, 1849; Robert Stephenson, Esq., M.P., President of the Institution, in the Chair.

The Chairman rose and said the Members must permit him to open the proceedings of the meeting by tendering to them his sincere thanks for the distinguished privilege they had conferred upon him, by electing him the President of the Institution of Mechanical Engineers. He assured them that he highly prized it, and would endeavour to prove himself worthy of it by attending with diligence and energy to the interests of the Institution. In undertaking that duty, it was not merely because he delighted in mechanical pursuits, but he was actuated also by the feeling that he should be doing honour to the departed. In undertaking it however, it was necessary that he should express to them how apprehensive he was—at least, that he had apprehensions—of an institution of that kind failing for want of energy on the part of its members. What had hitherto been the character of almost every institution of this kind in this country? Almost universal failure. It was a remarkable circumstance, that in a country like Great Britain, whose wealth and power were so closely connected with the development of the Mechanical Arts and Sciences—it appeared to him, in fact, a complete anomaly—that institutions of that kind should not appear to reach a higher standard than they now had. They saw Astronomers cultivate and maintain a society for extending their knowledge of the movements of the heavens. They saw Geologists maintaining and extending societies for investigating and developing the structure of the earth. They saw Physiologists and Botanists maintaining and extending their societies for investigating and developing the knowledge of

the animal and vegetable productions of the earth. Yet they had witnessed only languor and inactivity in the pursuit of those arts and sciences on which the nation's wealth absolutely depended. That it should be the case was to him the more remarkable, because the nation stood pre-eminent for their mechanical abilities. It was not egotistical in him to say this in Britain, because all foreigners conceded to them an unmeasured pre-eminence in those particular arts. Without despairing therefore of the success of the Institution, he felt that, in undertaking the task he was now doing, it was necessary that he should impress upon the Members the absolute necessity of co-operating with him with energy in the further development of the Institution. With that strong conviction on his mind, he wished also strongly to impress it on them; for without energy and industry they must fail as heretofore. He would endeavour to do his part, and trusted and hoped most sincerely that the Members would not fail in doing theirs, for without their assistance no efforts of his would sustain an Institution of that kind.

The minutes of the last General Meeting, held on the 24th of January, were read by the Secretary, and confirmed.

The CHAIRMAN said the first paper for the consideration of the meeting was

ON BAINES' RAILWAY CHAIRS AND SWITCHES.

This had been already read at the last meeting, but was not then discussed; the inventor, Mr. Baines, of Norwich, attended the present meeting to give further information and particulars on the subject. (See Report of Meeting, 25th January, 1849.)

Mr. BAINES exhibited and explained specimens of the joint and intermediate chairs. The Joint Chair had one jaw on the outer side, fitting close up to the head of the rails, and the rails were fixed by a horizontal dowel-pin, $1\frac{3}{4}$ inch wide and $\frac{7}{8}$ inch thick, which was passed through a notch in the end of each rail, and a corresponding hole in the outer jaw of the chair, and was drawn up by a vertical cotter driven through the dowel-pin on the other side of the chair. A wrought-iron plate 9 inches long was placed under the head of the dowel-pin, fitting close up to the head of the rails on the inner side; and this plate was drawn up tight against the rails by driving the vertical cotter, and

formed a stiff scarfing piece across the joint of the rails; this plate was a little cambered, and was sprung flat by driving the cotter.

The Intermediate Chair was intended to hold the rail without the use of a key; the two jaws were of the same form, both fitting up close to the head of the rail, but they were placed obliquely instead of opposite to each other; the chair was slipped endwise on to the rail, and then twisted at right angles to the rail, which made it grip the rail between the two oblique jaws. The chair was forced tight against the rail, either by screwed spikes with conical heads and eccentric countersink holes in the chair, which forced the chair further round and increased the pressure of the jaws on the rail when the conical head of each screw was drawn home into the countersink; or another plan for doing the same thing was by using square spikes, tapered to a greater breadth at the upper part where they passed through the chair, so that, by driving them down, the chair was forced further round against the rail.

An estimate was presented of the comparative expense of laying a railway on the above plan and on the ordinary plan, and the following were the respective amounts stated in it: the amount in each case being only the cost of the chairs, keys, and spikes, as the rest would be the same in each case.

	£.
The cost for a mile of single way, laid on the ordinary plan, with wood keys and iron spikes	348
The cost for a mile of single way, laid on the above plan, with square taper spikes	340
The same, with screwed spikes	363

but the square taper spikes were considered equally efficient, and they were more convenient than the screwed spikes for drawing out in repairs, &c., as well as less expensive.

The CHAIRMAN asked what trial had been made of these chairs.

Mr. BAINES said the only trial that had yet been made of them was a short length of line at the entrance of Norwich Station, which had been at work with these chairs for eleven months with complete success, and had not required any repair of the chairs. It was situated where all the trains ran over in entering the station.

The CHAIRMAN remarked that it was important for a trial to be made on a main line, where the trains were passing at full speed, because any iron fastening of that kind was liable to be affected by the speed of the trains. He asked whether the keys had ever got loose at all in the trial that had been made.

Mr. BAINES said a trial of the joint and intermediate chairs would be made shortly on the main line of the North Staffordshire Railway, at Danes Moss, near Burton. In the trial already made of them at Norwich there had not been any looseness of the keys of the joint chairs, and they remained just the same as when first put down. He had made a trial of the joint chair by removing the whole of the ballast away from under the joint sleeper; and the joint chair held the rail ends so firmly, that scarcely any deflection could be perceived when an engine passed over. He thought these chairs would do away with the canting of the joint sleepers, and would prevent a great deal of the noise in passing over the joints.

Mr. McCONNELL suggested that it would be preferable to make the dowel-pin with rounded edges, and the notches in the rail ends similarly rounded at the bottom, for the purpose of preventing any risk of the rails splitting from the angles of the notch.

Mr. BAINES said he did not see any objection to the proposal; but he thought there was not any risk of the rails splitting from the notch, because a clearance of $\frac{1}{8}$ inch was left between the dowel-pin and the top of the notch, so as to prevent any pressure ever coming upon the dowel-pin. The joint chair formed a coupling between the rail ends, and the rails supported one another.

The CHAIRMAN observed that, if this joint chair stood the test of the working on a main line, it would be the thing desired; but he feared there were too many parts about it to stand well. He considered the construction of some secure fastening for railway chairs was of the last importance for railways, and thought the subject well deserving the attention of the members; it was desirable to have as few parts as possible, and those not very costly.

Mr. WOODHOUSE asked how it was intended to replace a chair becoming loose or breaking; whether the rail would have to be taken out for the purpose.

Mr. BAINES said he proposed having some chairs cast wider in the jaws, which would allow them to be slipped on to the rail from the underside, for the purpose of replacing any broken chairs without taking out the rail. But he fully expected there would be very little breakage of the chairs, because there were no keys driven into them, and a great proportion of the breakage of the ordinary chairs was caused by driving the keys; also the new chairs were made stronger than usual; he had tried one of the intermediate chairs by suspending it from one of the jaws, and hanging a weight of 10½ tons from the other jaw for several weeks, and there was no failure in it.

He then explained the Switch, the principal improvement in it being the additional depth of the switch tongue, which was made about an inch deeper than the main rail; and the bottom flange of the switch tongue worked under the main rail when the switch was shut, for the purpose of driving under the main rail all the dirt that got between them in the working of the switch, instead of driving the dirt against the main rail, which was an evil in the ordinary switches where the rails were all of the same depth, and caused the risk of accident by the switch being prevented from closing properly. Another advantage obtained from this construction was that the bottom flange of the switch was kept entire to the end, instead of being planed off on one side as in the ordinary switches; and that increased the steadiness and strength of the switch tongue.

The CHAIRMAN remarked that the switch tongue was chamfered equally on both sides.

Mr. BAINES explained that the tongue was formed according to Mr. Wild's plan, with the point dropping under the head of the main rail; and the tongue was shaped exactly the same on both sides, so that the switch could be used either right or left handed.

The CHAIRMAN thought that was an improvement. He said they would be glad to hear the result of a trial when it could be made.

The Secretary then read the following paper by Mr. WILLIAM WEALLENS, of Newcastle-on-Tyne :—

DESCRIPTION OF AN EXPRESS ENGINE.

The Engine shown in the accompanying drawings was manufactured by Messrs. Robert Stephenson and Co., for the York Newcastle and Berwick Railway, in 1848; and is intended to run the express trains between Newcastle and York, a distance of 83 miles, as soon as the relaying of the line is completed which is now in progress. It was intended to have tried a series of experiments on the working of this engine, and to have accompanied the present drawings with the results of the experiments, but these have been unavoidably postponed in consequence of the relaying of the line; the engine is at present running between York and Darlington, and is working satisfactorily, with a small consumption of fuel.

This engine has inside cylinders with a crank axle, and six wheels; inside bearings for the crank axle, and outside bearings for the leading and trailing axles.

The cylinders are 16 inches diameter, and 20 inches length of stroke. The valves are vertical, and are placed on the outer side of each cylinder, instead of the inner side; the exhaust passages are carried under the cylinders, and unite at the blast pipe. The steam ports are 1¼ inches wide by 13 inches long, and the exhaust ports 2½ inches by 13 inches; the traverse of the slide valves is 4½ inches. The eccentrics are fixed on the ends of the crank axle outside of the wheels, and the valves are worked by the expansion link motion. The pumps are worked by the same eccentrics, and are fixed at the sides of the fire-box. The boiler is 3 feet 10 inches diameter, and 11 feet in length, containing 174 tubes of 1⅞ inches outside diameter, and 11 feet 5 inches length. The inside fire-box is 3 feet 9 inches long, by 3 feet 8 inches wide, and 4 feet 9 inches high from the top of the fire-bars to the underside of the roof.

The heating surface in the fire-box is		82	square feet
Ditto ditto	tubes	964	„
Total heating surface		1046	„

The driving wheels are 6 feet 6 inches diameter, and the leading and trailing wheels are 3 feet 9 inches diameter.

The outside and inside framing consist each of a single flat wrought-iron plate, 1 inch thick and 8 inches deep; the inside frame is bolted to a flange upon the cylinder and to a bracket on the fire-box; the outside frame is bolted to a flange upon the steam chest, which is in one casting with the cylinder, and is attached to the boiler by three wrought-iron brackets on each side.

The weight of the engine in working trim is about 22 tons.

Description of the drawings.

No. 1 is a side elevation of the engine and tender.
No. 2 is a longitudinal section of engine and tender.
No. 3, Fig. 1, plan of engine and tender.
Fig. 2, sectional plan of ditto.
No. 4, Fig. 1, elevation of engine at the fire-box end.
Fig. 2, cross section through the boiler.
Fig. 3, elevation of engine at the smoke-box end.
Fig. 4, cross section through the cylinders.
No. 5 shows the working gear on an enlarged scale.

The CHAIRMAN observed that this engine did not differ materially from the ordinary express engines, except that the steam chests were brought outside and the eccentrics placed outside the driving wheels. He might state that he had seen the engine, and the consumption of coke including getting up the steam was 18 lbs. per mile with the express trains, which were generally very small, having only three or four carriages.

Mr. MCCONNELL remarked that the distance from the valves to the cylinders was longer than usual, and would be a little loss in steam; otherwise in several respects it was a convenient arrangement.

Mr. BEYER thought the parts got more spread about by that arrangement.

Mr. MCCONNELL observed that it appeared to be the intention to lower the centre of gravity, by removing the eccentrics from under the boiler; there would be an advantage in the valve faces being very easy to get at for repairs, in consequence of being placed outside.

The CHAIRMAN then called upon Mr. HENRY SMITH, of Westbromwich, to read his paper

ON A SOLID WROUGHT-IRON WHEEL.

The subject of the present communication is a new Wrought-Iron Railway Wheel, which is forged solid in one piece, and is manufactured entirely by the forge hammer; the wheel is disc-shaped, the disc portion being about $\frac{5}{8}$ inch thick, and gradually swelled out to the thickness of the nave and the tyre.

The following may be stated as the chief desiderata in a railway wheel:—

1.—The greatest possible strength with the least possible weight.

2.—Durability, implying also facility of repair.

3.—Economy in cost.

On the first of these points it is conceived there will be no difference of opinion about the disc shape being the strongest possible; and also that, when a wheel is made in one entire piece, it must necessarily be less liable to the effects of wear and tear, than one which is composed of a number of pieces. This will be made more manifest by analysing the mode of manufacturing railway wheels in the old or ordinary way. For this purpose, and for the sake of drawing the fairest comparison between the wheel now under consideration and the ordinary wheels, a wrought-iron wheel is selected of the most improved make, as shown in drawing A, having a wrought-iron nave, with the spokes welded to the nave and to the inner tyre.

The following is the mode of manufacture of this latter wheel. Pieces of iron, as shown by drawing B, with wedge-shaped ends, are brought together, all converging to a common centre. These are then welded together to form the nave or boss and the inner ends of the spokes of the intended wheel. Other pieces T shaped, as represented by the drawing C, are then welded to the ends of these spokes and again to each other, forming the inner tyre of the wheel. This done, a rolled tyre-bar of a suitable length is bent into a circle of a proper diameter to go on the inner tyre, and is welded to form a perfect circular hoop. This hoop is then heated in a furnace and put upon the inner tyre; and then the wheel is immersed in cold water, to occasion such an amount of contraction of the tyre as shall firmly fix it upon the wheel. Rivets or bolts are then passed through both, to secure them together.

Now it is submitted that the whole process of thus producing a wheel is open to many well-founded objections, such as the following:—

The possibility of a want of dexterity in the manipulation of the different parts, in the making and bringing them together. The chance of doing so when the iron is not in a proper condition for welding. Then the uncertainty of the hoops or tyres being exactly the same length, or the wheels with the inner tyre of precisely the same diameter. And again, the amount of contraction of the outer tyre, depending upon its slow or rapid cooling, will be affected by any variation in the temperature of the wheel itself and of the water in the "bosh" or cooling cistern; and these of course cannot be kept uniform. All these circumstances are opposed to wheels being well made with *loose* tyres, whether with wrought-iron naves and arms or with cast-iron naves.

In reference to the second head—durability—it is conceived, from the contingencies already alluded to, that it must be obvious a wheel made in one piece will be the more lasting; but on this

point the wheel which forms the subject of the present enquiry has other claims to prefer.

In consequence of the iron in the wheel being both granular and laminar (inasmuch as by the mode of manufacture hereafter explained this result is ensured), and the grain of the iron being brought to stand at right angles to the direction of the wear, and the body of the iron being of a denser and more compact character than rolled iron, it must doubtless be much stronger and more durable than any rolled tyre-bar of piled iron, which is liable to lamination, and altogether of a softer nature.

Again, the torsive and abrasive effects of the carriage-breaks will not produce the same results on a solid disc wheel as on one with a loose hoop or tyre of rolled iron.

Then as regards repairing, when the tyre of the disc wheel is worn down so much as to require a renewal, the wheel can be put in the lathe and turned cylindrical, to receive a tyre in the ordinary way, secured on as shown by drawing D, by bolts screwed into the tyre from the inner side, or by countersunk rivets through the tyre; and it must be then a better wheel than any yet manufactured.

On the subject of cost, it can only be observed at present that, as the first expense does not determine this point, it must be left to be settled by the results of a sufficient experience.

The following is a description of the mode of manufacturing the new solid disc wheels. In the first place, a straight bar of hammered or rolled iron is taken, of 4 or 4½ inches width, or more if required, and sufficiently long to form a hoop of such a diameter as is most suitable to make the intended wheel. Other pieces of bar iron are then laid flat and close together and cut in lengths to the same circle as the hoop, to form the base of a "pile;" the hoop is then placed upon this foundation, and filled with scrap iron. The whole is then put into a reverberatory or heating furnace, and when at the proper heat is hammered in the tools or dies shown by drawing E, to form a "mould;" the face of the hammer is recessed in such a shape as to form an approximation to the shape of one side of the intended wheel, but only about two-thirds of the diameter; and the anvil face has a circular recess flat-bottomed, into which the hammer face enters. Two of these "moulds" are then put together back to back, heated in a similar way, and hammered between the tools or dies F, which are of the same sectional form and nearly the full-size scale of the finished wheel; but these tools embrace only a segment of about one-fifth part of the entire wheel. The "mould" is turned round horizontally during this process, being turned a little between each blow of the hammer; and it is thus hammered out to the form and size of the required wheel. The wheel is then put into an annealing furnace, and is planished between tools similar to the last,

which are of the form and the full-size scale of the finished wheel, as shown by drawing G; and the wheel then only requires the tyre and the nave turning in a lathe, and the centre boring out. The finished wheel is shown in drawing K.

By this mode of manufacture it will be perceived that Low Moor iron, or any other description of iron or steel, can be used if required for the tyre of the wheel, and thus in all cases ensure a clean wearing surface, and a compound character of fibrous and granulated iron, which it is believed no other system of making wheels affords.

The centres for large spoke wheels are also manufactured in one solid piece in a similar manner, by the tools or dies shown in drawing H; the top and bottom tools are both alike, and are recessed in the form of the nave of the intended wheel, with a short portion of each of the spokes radiating from the nave. The centre of the wheel is thus stamped out by the hammer, with a portion of each of the spokes, about a foot long, ready for welding on to the T pieces to form the inner tyre and the remaining portion of the spokes. A thin web or fin is left in the centre between the spokes, which is afterwards cut out by the smith. The object of this construction is to surpass in certainty of soundness the precarious method of making them at present in use.

It is unnecessary to urge the importance of obviating as far as possible the occurrence of such accidents as have too frequently happened in consequence of defects of railway wheels; but a few of these cases may be alluded to here, in illustration of the subject.

The accident on the Edinburgh and Northern Railway in October last, when the tyre of the leading wheel of the engine broke and threw the train off the line.

That on the East Lancashire Railway in November last, where the tyre broke of one of the carriage wheels.

That upon the Brighton Railway in September last, when the tyre of one of the engine wheels broke, throwing the train off the line.

And that upon the Great Western Railway, about two years ago, where the tyre of a carriage wheel broke, and a portion of it broke through a carriage, causing a fatal accident.

With the view of obtaining some practical information upon the comparative resistance of the air to the revolution of the disc wheels and of the ordinary spoke wheels, some experiments have been tried at the Vulcan Iron Works, Westbromwich, by the author, with the assistance of Mr. Marshall, the Secretary of the Institution; and the results of these experiments are appended in the following Table.

Experiments on the Resistance of the Air to the Spokes of Wheels.

Vulcan Iron Works, 17 *April*, 1849.

No. of Experiment.	Description of Wheel.	Weight of Wheel.	Weight suspended on rope.	Distance fallen by Weight.	Total Time of revolution of Wheel.	Total Revolutions of Wheel.	Average Speed per hour of Wheel.	Length of Rope.	Time before rope was detached.	Revolutions before rope was detached.	Weight of Tail Rope.	
No.	Wheel.	Lbs.	Lbs.	Feet.	Seconds.	No.	Miles.	Feet.	Seconds.	No.	Lbs.	REMARKS.
1	Losh	451	56	270	55	148	17	270	15	38	0	No tail rope; the rope was detached before weight touched bottom of pit.
2	Disc	414	56	270	62	161	17	270	15	38	0	
3	Losh	451	56	279	60	166	18	355	17	50	7	With tail rope.
4	Haddan	423	56	279	$60\frac{1}{2}$	176	19	355	17	50	7	Ditto
5	Disc	414	56	279	68	220	21	355	17	50	7	Ditto
6	Disc	414	56	279	66	222	22	355	17	50	7	Ditto
7	Disc	414	$71\frac{1}{2}$	279	75	257	22	355	12	50	7	Ditto, and stone fixed on iron weight.

These experiments were performed at an old mine shaft 279 feet deep, and the apparatus is explained in the accompanying drawing I.

The axle was placed across the top of the shaft and carried by two bearings with brass steps; the wheel under experiment was fixed on one end of the axle outside the bearing, and the counter connected to the other end of the axle. The counter was so graduated and arranged that the most correct observation could be taken of the number of revolutions completed in each case.

A drum 2 feet $3\frac{1}{2}$ inches diameter was fixed on the centre of the axle, and a rope $\frac{3}{8}$ inch diameter was coiled on the drum, with the moving weight attached to the end of it hanging over the centre of the shaft; the other end was not attached to the drum, but held only by the grip of the second turn of the rope, so that, when the rope was run off the drum by the weight falling to the bottom of the shaft, the end of the rope detached itself from the drum without any check. As there was not any means of descending the shaft to bring up the rope and weight, a tail rope of the same length and size as the main rope was attached to the weight at one end, and the other end made fast at the top of the shaft, the rope hanging double halfway down the shaft; this served to bring up the weight and main rope after they had fallen to the bottom of the shaft in each experiment. These two ropes weighed 7 lbs. each, and the weight of the main rope caused a gradual acceleration in the moving weight, varying from nothing at the beginning of the descent to 7 lbs. at the end; whilst the tail rope, acting at first with half its weight, caused an increase varying from $3\frac{1}{2}$ lbs. to nothing at the end. The result was therefore a total increase of the moving power varying from $3\frac{1}{2}$ lbs. at the beginning of the fall to 7 lbs. at the end; and as this was the same in each case and the moving weight was also the same (56 lbs.), its effect may be neglected in ascertaining the comparative results for the present purpose.

The wheels tried in the experiments were one of the solid wrought-iron disc wheels, a wrought-iron flat-spoked wheel of Losh's pattern, with spokes $3\frac{1}{16}$ inches broad, and a wrought-iron flat-spoked wheel of Haddan's pattern, with spokes $3\frac{1}{16}$ inches broad. These wheels were selected as near the same weight as was practicable, Losh's wheel being one-eleventh heavier than the disc wheel, and Haddan's wheel one-forty-sixth heavier than the disc wheel; all the wheels were 3 feet diameter.

In the four experiments Nos. 3, 4, 5, and 6, (see the Table on page 13) the time in which the rope was run off the drum was the same in each case, 17 seconds; and as the number of revolutions in that time was also the same in each case, 50, in consequence of the same rope being used, it follows that the velocity of the wheel at the moment of the power being detached was the

same in each case, and consequently the comparative resistance in each case is indicated by the comparative length of time that the wheels continued in motion after the power was detached.

In the experiments Nos. 1 and 2, the weight and rope were dropped down the shaft without the addition of a tail rope to pull them up again; and the rope was shortened to 9 feet less than the depth of the shaft, so as to ascertain the exact moment of the power being detached from the drum.

The time was the same in both cases, 15 seconds from starting to the power being detached, and the number of revolutions also the same, 38: this gives an average velocity of the circumference of the wheel from starting equal to 16 miles an hour, or a final velocity of about 32 miles an hour at the moment of the power being detached.

In No. 1 experiment with Losh's wheel the total time of the wheel revolving was 55 seconds, and in No. 2 experiment with the disc wheel it was 62 seconds; then deducting in each case the 15 seconds during which the power was in action, the results are 40 and 47 seconds respectively for the time of motion after the power was detached: which are in the proportion of 100 to 118, showing that 18 *per cent. more resistance* was experienced by the spoke wheel than by the disc wheel. In the four experiments, Nos. 3, 4, 5, and 6, the time was 17 seconds from starting to the moment of the rope being detached; and as the rope was in these cases longer than the depth of the shaft, so that the weight stopped at the bottom before the rope was detached from the drum, 14 seconds may be taken as the time during which the power was acting; in Nos. 1 and 2 experiments, where the weight of the tail rope was not acting, this time was ascertained to be 15 seconds.

In No. 3 experiment with Losh's wheel the total time of the wheel revolving was 60 seconds; in No. 4 with Haddan's wheel it was 60½ seconds; in No. 5 with the disc wheel the total time was 68 seconds; and in No. 6 with the same wheel 66 seconds, the mean time of the disc wheel being 67 seconds.

Then deducting in each case the 14 seconds during which the power was in action, the results are 46 seconds with Losh's wheel and 53 seconds with the disc wheel, for the time of motion after the power was detached: which are in the proportion of 100 to 115, showing that 15 *per cent. more resistance* was experienced by the spoke wheel than by the disc wheel.

The average result from both sets of experiments is 16½ per cent. difference of resistance in favour of the disc wheel; and this is attributable to the additional resistance of the air caused by the flat spokes of the spoke wheel, as the friction of the axle caused the same resistance in each case, the weight being nearly the same of each wheel; and to prevent any change in the friction of the axle, the wheels were changed without taking the axle out of its

bearings during the experiments. The axle journals were $2\frac{1}{4}$ inches diameter and $2\frac{1}{2}$ inches length; and the friction of the journals was overcome by a weight of $15\frac{1}{2}$ lbs. acting on the drum, when the wheel was upon the axle, and by a weight of $5\frac{3}{4}$ lbs. when the wheel was taken off.

As these experiments were made with wheels revolving on a stationary axle, it is requisite to consider what would be the comparative effect, if the wheels were rolling on their circumference whilst revolving at the same rate on their axle, as in the practical case of the wheels of railway carriages running on a railway. In the former case the motion of the spokes is at a uniform velocity, and always at right angles to the direction of the spokes; but in the latter case of a rolling wheel the motion of the spokes is at a varying velocity, and always inclined obliquely to the direction of the spokes, except at the moment of each spoke being in the vertical position. This is illustrated by the accompanying diagram, where the successive positions of the spokes are shown. The outer ends of the spokes move in a cycloidal curve, having double the velocity of the revolution of the wheel when they arrive at the top of the wheel, but becoming stationary at the moment of touching the rail at the bottom of the wheel; the average velocity of the outer ends of the spokes is about $1\frac{1}{4}$ times greater than when the wheel revolves on a stationary axle at the same rate of revolution. The average velocity of the inner ends of the spokes is about 3 times greater when rolling than when revolving on a stationary axle. As the resistance of the air increases in proportion to the square of the velocity, the average resistance to the outer and inner ends of the spokes will be about $1\frac{1}{2}$ and 9 times respectively greater in the former than in the latter case. But this is reduced by the oblique position of the spokes as regards the direction of their motion in the rolling wheel; the motion of the spokes being twice during each revolution in the direction of the spokes, and consequently the resistance of the air reduced to nothing at those points. By measuring upon the diagram the comparative velocity of several points in a spoke in various positions during a complete revolution of the wheel, and the inclination of the spoke to the direction in each of these positions, the following approximate result has been obtained:—that the total resistance of the air to the spokes when the wheel is rolling is 3 times the total resistance to the same spokes when the wheel is revolving at the same rate of revolution on a stationary axle.

It follows that the result of the foregoing experiments has to be multiplied by 3; and consequently the excess of the resistance of the air to the spoke wheel over the disc wheel would have been 3 times $16\frac{1}{2}$, or $49\frac{1}{2}$ per cent., if the wheels had been rolling in this case instead of revolving on a stationary axle. This excess of resistance of the spoke wheel would not be so great in

the practical case of the wheels of a railway carriage running on a railway, as the friction of the axle journals is greater in that case than in the experiments, from the weight pressing upon them being greater; and consequently the resistance of the air to the spokes of the wheel would then bear a less proportion to the friction of the axle journals.

The CHAIRMAN said he thought the thanks of the meeting were due to Mr. Smith for his very interesting communication; and he moved a vote of thanks to him, which was passed.

Mr. SMITH exhibited a finished specimen of his wheel, and one of the moulds in the first stage of manufacture; also a centre for a wrought-iron spoke wheel, which he had manufactured that day; it rang as clear as a bell when struck by a hammer.

Mr. McCONNELL said he had tried two pairs of these wheel centres at Wolverton, and had found them perfectly solid, and they were an excellent job; they were for the leading and trailing wheels of an engine, 3 feet 9 inches diameter.

Mr. SMITH said, in answer to questions, that his hammer with which the wheels were forged was rather more than 9 tons weight; it was a helve taking up under the belly, and was driven by bands. The weight of the finished disc wheel was about $4\frac{3}{4}$ cwt.; it was made with the first tools that he had started with, and he had adhered at present to his original section of wheel, but he did not profess it to be the best form of section that might be adopted. He had made about 200 of these wheels; there were some now at work on the Birmingham and Gloucester line, and he had an order to prepare some for the travelling post-office to register the number of miles run by them. As to the cost of these wheels, he was ready to put himself in competition with other parties.

The CHAIRMAN remarked that the durability or life of the body of the wheel was so very much greater than that of the tyre of the wheel, which must be renewed when only about a tenth of the life of the wheel was gone, and would then require a secondary process to put on the new tyre; and consequently it appeared to him preferable not to incur any additional expense and trouble by

forging the tyre on to the wheel, but to manufacture the disc alone, and put on a separate tyre in the first instance.

Mr. SMITH replied that it was not any more trouble to forge the wheel with the tyre than without it; it was easily done, and the cost of manufacturing the wheel would be less than putting on a separate tyre. There would be a little more trouble and expense in re-tyring the wheel for the first time; but he thought that the iron of the tyre would be much more durable than any rolled tyre could be, on account of the process of manufacture.

Mr. WOODHOUSE asked what advantage the wheel would possess over a cast-iron wheel, if it were forged without the tyre; but he thought there was certainly danger of fracture from expansion in a cast-iron disc wheel.

Mr. BEYER remarked that he had seen some cast-iron wheels which he thought would last as long as wrought-iron ones, and he never could understand why they were not more used; there were many wheels of cast-iron, even large driving wheels of 6 feet diameter, that had been running many years; and he thought it was an important question of economy in railways.

The CHAIRMAN observed that when locomotive engines were begun, some 25 years ago, they were driven to wrought-iron wheels, and thought it a great advantage; and he thought that for rapid railway travelling they must admit, as a body of engineers, that wrought-iron was better than cast-iron for such purposes. The present facilities for the manufacture of wrought-iron had been so strikingly shown to them on the present occasion, that he thought it was hardly possible to save anything worth mentioning by the adoption of cast-iron, particularly in the expense of a pair of large driving wheels.

Mr. SMITH said he had been informed that the tyres were found to wear longer on solid wheels than on spoke wheels.

The CHAIRMAN remarked that the tyre of large wheels would no doubt deflect between the spokes, and this would not be the case with a disc wheel; there was certainly a bending process going on which might contribute to the wear and tear. But judging from the effects of rigidity in the wear of rails, he thought the tyre would wear faster on a rigid wheel; it was certain that rails laid on a block road wore much faster than when laid on an elastic road, and the difference in their wear was very marked.

Mr. MIDDLETON observed that Mr. Ephraim Boulton had a patent for a disc wheel, and many of them had been used on the Great Western Railway, but they were not approved, and were all cast aside.

The CHAIRMAN said he believed those wheels were a double disc, and the tyre was riveted on; he understood that one principal reason for their being discontinued was the singular drum-like noise they made.

Mr. ADAMS said that those wheels were made with two wrought-iron discs, riveted to a ring of T iron to form the inner tyre, and riveted to the two faces of a cast-iron nave which was turned to receive them; they had been in use eight years, and he thought they would last many years, and were as good wheels as the one under consideration, and much cheaper; he did not know why there had not been more of them made.

Mr. SMITH observed that, by forging the tyre solid on the wheel, the risk of accident from the breaking of the tyre would be avoided whilst the original tyre lasted; and he thought that advantage was worth ensuring, as many accidents had been caused by the tyres breaking or coming loose.

Mr. BEYER asked whether the wheels were all as good as the specimen exhibited to the meeting; and whether the two moulds of which the wheel was made were always perfectly united at the outer face of the tyre.

Mr. SMITH said he would guarantee the wheels to be all as good; and the moulds were united as thoroughly and soundly in the forging as the bars in piled iron.

Mr. SLATE asked if he could tell what would be the probable wear of these wheels; but Mr. SMITH said there had not been sufficient experience of their working to ascertain that.

Mr. ALLAN remarked that the disc part of the wheel was almost everlasting; it would last a hundred years; but the tyre would not last more than three years.

The CHAIRMAN said it was certainly a very good wheel, independently of the question of the tyre; and he was of opinion that the railway world was very likely to be greatly indebted to Mr. Smith for his very excellent wrought-iron wheel; and he saw no reason why it should not come into extensive use. About

the tyre, he had yet some doubt whether it was desirable or essential, for the sake of a small portion of additional safety for two or three years, to forge the tyre solid with the wheel. He thought the mode of manufacturing the wheel was highly interesting, and it was a triumph in forging that he was not prepared for.

The Secretary then read the following paper, communicated by Mr. JAMES W. HOBY, of Brighton :—

ON THE CONSTRUCTION OF PERMANENT WAY.

The subject on which a few remarks are here offered for consideration seems hardly to fall within the scope of this Institution; there exists however such an intimate connection between the construction and condition of the Permanent Way and the performances of the motive stock, as regards speed, economy, and safety, that little further apology need be made for the introduction of a few observations on the various kinds of permanent way now in existence.

The rapid deterioration of the permanent road on most of the leading lines of railway, since the introduction into general use of a class of engines considerably more powerful, and by consequence larger and heavier, than those in use four or five years ago, has been such as to attract the notice of the public, and to call forth the anxious attention of those on whom more immediately devolve the duties of engineering and management.

That there has been deterioration, more especially in the rails themselves, and that it has been lately manifesting itself far more rapidly than had been calculated upon, is evident from the additional strength now given by most engineers to the rails and other parts of the permanent way, in order that repairs may be less continuous, and renewals less frequent.

If the question be regarded in a general view as connected with economy, whether of first cost or annual maintenance, it will be manifest that these two points have an essential bearing on each other. A system of road may be expensive in its first construction, yet cost so little in maintenance, and last so long a time, as to be in the end far cheaper than a road less expensively formed, but requiring greater annual outlay, and more speedy replacement.

Circumstances being equal, the annual cost of maintenance distributed over a period of years, and including both labour and materials, should form a very distinguishing test to apply in ascertaining the merits or defects of the different constructions of permanent way now in use; for it may fairly be argued that the road which costs least to repair will also last the longest, a state of efficiency and security being presumed.

Acting on this view, the writer has endeavoured to collect such facts in regard to mode of construction and cost of maintenance on different lines, as might suffice when collated to determine the most advantageous and ultimately economical mode of construction, as well as to obtain some practical information as to the points wherein existing systems appeared weak or defective; and had intended simply to offer these facts, so far as they might be useful, for the consideration of the members of this Institution. But in pursuing this investigation, and attempting the proposed comparison, it became apparent that the cost of maintenance was controlled by elements not only not common to the different systems under consideration, but varying even on contiguous portions of the same line; these elements being, the nature of the substratum, or material of formation; the character of the ballast; and the extent and kind of the traffic;—circumstances which, whilst they render it difficult to arrive at any accurate average of the cost of maintenance on any particular line, make it impossible to deduce satisfactory results from a comparison of those averages.

It therefore becomes necessary to take up the question more at large, and to ascertain the conditions of stability and efficiency which are required in all permanent way, and the manner in which the various systems at present in use meet these conditions.

The principal of these conditions may be arranged as under:—

1.—Sufficient platform or bearing surface on the ballast to prevent the whole road from being crushed down into the ballast.

2.—Sufficient bearing surface of the various parts one on another to prevent their crushing into each other.

3.—Sufficient cross ties to secure uniformity of gauge between the two rails composing one line of way.

4.—Sufficient side stiffness in each rail.

5.—Suitable strength, quality, and shape of materials, to prevent their crushing in themselves.

6.—Such general precautions as shall tend to the protection and preservation of the more perishable portions from atmospheric and other influences; on this last point however it will not be within our limits to enter.

These conditions satisfied, the questions of economy and simplicity of construction remain for consideration.

The bearing surface of the permanent road on the ballast has been variously provided. Amongst the more prominent of the modes now in use we may notice roads laid upon—

1.—Stone blocks.

2.—Cross sleepers of usual make.

3.—Cross sleepers of usual make, brought nearer together at the joints, with a larger sleeper under the joints.

4.—Cross sleepers of triangular section.

All of the foregoing usually sustain and secure the rail by the intervention of chairs.

5.—The longitudinal bearer, used on the broad-gauge lines.

6.—The same, as laid on the narrow-gauge at London Bridge.

7.—A combination of the cross sleeper with the longitudinal bearer, now in use on the Midland Great Western Railway of Ireland, and formerly laid down on the Croydon line.

In these three plans, a flat-bottomed rail or a bridge rail is bedded on and secured directly to the longitudinal bearer.

8.—And lastly, the system introduced on the South Coast lines, and on the Great Southern and Western of Ireland, in which a bridge rail is fastened immediately to cross sleepers. The cross sleepers, in the case of the Southern and Western of Ireland, vary considerably in size, and are placed at proportional distances, the great body of the support being under the joint.

Briefly to compare the amount of bearing surfaces respectively presented to the ballast under the several systems mentioned above, it will be found that, assuming a length of rail at 18 feet,

1.—With stone blocks there are
 1·33 square feet per foot run of rail.

2.—With cross sleepers of usual make equally distributed,
 1·12 square feet per foot run of rail.

3.—With the same brought nearer together at the joint,
 1·36 square feet per foot run of rail at the joint, and for 4 feet 1½ inch each side of joint; and
 1·04 square feet per foot run of rail, for the 9 feet 9 inches remaining to make an 18 feet length.

4.—With sleepers of triangular section rather more surface is presented to the ballast.

5.—With the longitudinal bearer used on the broad-gauge lines,
 1·25 square feet per foot run of rail.

6.—With the longitudinal bearer used at London Bridge,
 1·17 square feet per foot run of rail.

7.—With the combination of the longitudinal and cross sleepers used on the Midland Great Western of Ireland,
 1·43 square feet per foot run of rail; and in cases where more sleepers are introduced on boggy or peaty ground on the above line, or in the road on the Croydon line,
 1·75 square feet per foot run of rail.

8.—With the construction adopted on the Great Southern and Western Railway of Ireland, a general average of

1·50 square feet per foot run of rail; the proportions varying from
2·50 square feet per foot run of rail at joint, to
0·93 square foot per foot run of rail in centre of rail.

The next point for attention is the amount of bearing surface of the several portions of the permanent way one on the other, necessary to prevent their crushing into each other.

On instituting a similar comparison to the previous one, it will be found that, assuming as before an 18 feet length of rail,

1 and 2.—With stone blocks and cross sleepers placed at equal distances apart, which may be regarded as the older forms of construction, when rather light chairs were used, there are
20 square inches per foot run of rail at the joint, and
17 square inches per foot run on the remaining length.

3 and 4.—With cross sleepers brought nearer together at joint, of usual make, or of triangular section, with large chairs,
23¼ square inches per foot run of rail at joint, and for 4 feet 1½ inch on each side of joint; and
16⅛ square inches per foot run of rail for the 9 feet 9 inches remaining to make up 18 feet.

5, 6, and 7.—With the longitudinal bearer used on the broad-gauge lines and at London Bridge, and with the construction used on the Midland Great Western Railway of Ireland, and on the Croydon line,
60 square inches per foot run of rail.

8.—With the cross sleepers to which a bridge rail is immediately attached, on the Great Southern and Western of Ireland, a general average of
16 square inches per foot run of rail, in proportions varying from
27 square inches per foot run of rail at joint, to
10¼ square inches per foot run of rail in centre of length.

It must be remarked that in these last four instances, whether with bridge rails or flat-bottomed rails, packing plates are placed under the joints, and in the road at London Bridge at intervals along the rail, to prevent it from burying itself in the timber, more particularly at the joints; and that on the broad-gauge lines a packing of hard wood is introduced between the rail and the bearer, which presents to the longitudinal timber a surface of 108 square inches, or ·0·75 square foot per foot run of rail, through which the fastenings for securing the rail pass.

The modes adopted for the preservation of the gauge next claim our attention.

With stone blocks there is no provision for this beyond the stability of each individual block.

With cross sleepers this essential object is very completely secured.

With longitudinal bearers this point is secured by cross timbers with strap bolts: these bolts securing the longitudinal timbers hard up against the ends of the cross pieces.

In the case of the Midland Great Western Railway of Ireland and the old Croydon line, as has been before mentioned, cross sleepers are used with the longitudinals.

The next point for consideration is the side stiffness in each individual line.

With stone blocks, and with cross sleepers, whatever be the kind of rail used, the side stiffness depends entirely on the strength of the rail itself to resist lateral strain between the points of support.

The rails used with longitudinal bearers are in themselves very stiff laterally, whether of the bridge or flat-bottomed section; and their immediate connection with the longitudinal bearers gives a further amount of side stiffness to this construction.

From the foregoing remarks we collect that stone blocks as a means of support on the ballast, although presenting a large amount of bearing surface on the ballast, and being in themselves solid and stable, neither retain the road in gauge, nor secure the correct continuous elevation of the different points of support in the same line of rail; and as from this circumstance their use is chiefly confined to cuttings, where the substratum is hard, and the ballast good, their hardness gives a peculiar harsh and grating feeling to the carriages passing over them.

The situations now are comparatively few in which stone blocks can be procured for cost to surpass the wooden sleepers, especially when the labour of jumping and plugging the holes for the chair pins is taken into account. It is however to be remarked that in cases where horse power is used they have the advantage of leaving a clear way for the horses' feet.

Cross sleepers, which have on the narrow-gauge lines been so extensively adopted, whilst presenting a very sufficient bearing surface on the ballast, unite in themselves a cross tie to preserve at every point of support uniformity of gauge, and are readily packed and adjusted. Triangular-sectioned sleepers present theoretically a very large bearing surface to the ballast to resist downward pressure; it is doubtful however whether, except in ballast of a very firm and binding character, this effect is got

from them, as in coarse and open ballast the sharp edge of the sleeper has a tendency to work downwards into the ballast with the motion of the trains, and to cant with the driving forward of the rails, a defect to which all cross sleepers are more or less liable. These last sleepers have the great advantage of being surface packed, so that repairs can be effected without the removal of a large quantity of ballast.

For side stiffness between the points of support, both with stone blocks and with the various kinds of cross sleepers, the lateral strength of the rail is alone depended on; and in this respect the double T rails so extensively used seem open to some objection, for to their deflection sideways with an engine slack in gauge, or travelling at a high velocity, may be attributed much of the side oscillation so observable at times, which a variation of speed will often check.

The writer is aware that it has not been usual to attach much importance to this question; and in Professor Barlow's valuable work, in commenting on the small amount of side deflection as indicated by experiments in what were then considered most unfavourable circumstances, Professor Barlow says (page 421):—

> "The whole of these experiments" (on the lateral deflection of railway bars) "have a tendency to show that the stress which "the bars have to sustain in this direction is not such as to "require to be more amply provided for than the increased thick-"ness the bar must have to meet the greater vertical strain due "to a longer bearing. In other words, the additional strength "given to the bar for the purpose of resisting the vertical strain "will be amply sufficient to meet and resist the lateral strain."

That is to say, the rails then experimented on were deemed strong enough laterally; and it was held that further increase of strength vertically, necessary for a longer bearing, or, we may add, to support heavier loads, would suffice to impart the requisite lateral strength to the rails.

The weight of the engines since Professor Barlow conducted these experiments has been doubled and even trebled, the weight on the driving wheels more than doubled, and the speed, no unimportant element in producing side oscillation, has been almost constantly doubled, and on special occasions quadrupled; the weight of the rails has crept up from 45 or 50 lbs. per yard to 75, 80, 90, and even 100 lbs. per yard, but the side stiffness has by no means proportionally increased.

In cases where even 70 lbs. rails have been tried with long bearings, the side oscillation has been found so constant and violent as to necessitate a recurrence to the shorter bearings most in use, from 3 feet to 3 feet 6 inches.

The longitudinal bearers have the advantage of presenting a continuous bearing surface to the ballast, and of giving with the rail great and uniform side stiffness to each line of rail, so that comparatively few cross ties are needed to keep the line in gauge, those on the broad-gauge lines being 15 feet apart. To these two main features—continuity of bearing on ballast, and continuity and amount of side stiffness—are to be attributed the great ease and evenness of the motion of the engines and trains on the Great Western Railway.

This system of construction is open to the following objections:—the expansion and contraction of the rails tend to loosen the fastenings, especially at the joints; and from this cause, with the comparatively complex nature of the cross ties, the maintenance is more expensive than on ordinary roads laid on cross sleepers; and it seems difficult to lift this road without great care and attention. When a cross sleeper is used under the longitudinal bearer, securing at the same time correctness of gauge and of the cant of the rail, this objection vanishes; and the cross sleeper being raised and packed, the longitudinal timber may be packed subsequently. This last construction, as used on the old Croydon line, stood a very large amount of traffic, although laid on a substratum of a very inferior character.

Where a bridge rail is laid down directly on cross sleepers, the rail undoubtedly possesses in itself considerable side stiffness between the points of support; it does not however contain so much vertical strength to resist deflection as the ordinary double T rail, and the expansion and contraction of the rail are apt in cases to split the joint sleepers. The proportions in which, on the Great Southern and Western of Ireland, the bearing surface on the ballast is varied (from 2·50 to 0·93 square feet per foot run of rail), give so great a preponderance to the joint that it may be doubted whether in practice it will not be found that constant packing is required in the centre of the rail lengthwise; and the amount of bearing surface of the rail on the sleepers is so small that there will be much crushing of the rail into the timber, especially on the curves.

Having made these general remarks on the various peculiarities of some of the leading modes of constructing permanent way, it remains to consider the shape, strength, and quality of the materials used, to prevent them from crushing in themselves. This more immediately applies to the rails, or wearing surface of the permanent way. It is in this respect that most of the systems have alike suffered since the introduction of the heavy engines now in use.

The rails most in use vary from 2¼ to 2½ inches in width on the upper table or wearing surface, and are for the most part made

rounding at the top. Now if we look at the line of contact of a tyre on a rail, it will be found that a comparatively small portion of the width of the rail, in favourable cases not more than $1\frac{1}{4}$ inch, and in some instances less than $\frac{1}{2}$ inch, is in actual contact, as shown in Drawing No. 1, Figs. 1, 2, 3. If it be assumed that on a 5 feet 6 inch wheel of an engine in working order a weight of 6 tons has to be carried, and if the strength of the iron in large railway bars to resist compression be taken at 8 tons per inch—and it is doubtful whether more may be taken—then the line of contact of the tyre on the rail in section being $\frac{3}{4}$ inch, it is obvious that such line of contact will have to be extended in the other direction into a surface of 1 inch, before the surface of the rail in contact with the tyre becomes sufficient to resist the weight superimposed, and the amount of compression in the rail will be represented by the versed sine of the chord of an arc 1 inch long with a radius of 2 feet 9 inches. The limit of compression of iron, such as is used in railway bars, being determined, it is evident that the amount of bearing surface between the rail and tyre will vary directly with the weight superimposed; that its extent in the length of the rail, or the length of the circumference of the wheel in contact, will vary with the length of the line of contact in section; and the extent of the compression, or length of the versed sine, will vary with the radius of the wheel.

The amount of this permanent compression, or of the motion produced in the particles of the iron beyond the elastic limit, even supposing all the compression to take place on the rail and none on the tyres of the wheels, will evidently be infinitely small; but it may be fairly argued that such motion does take place, and, renewed from time to time, from infinitesimal and insensible becomes palpable and evident in its results.

It is difficult on other grounds to account for the rapid deterioration of rails—the word deterioration being used in contradistinction to destruction, as the rails now removed on some of the leading lines have in many cases lost little more than 2 lbs. per yard of their original weight: showing that, although rendered useless, they have not given out a fair amount of wear to the companies. For this information the writer is indebted to Mr. Dockray, and would take this opportunity of acknowledging the kind courtesy of that gentleman in permitting access to his very valuable report on this subject.

The cause of the removal of rails when not thoroughly worn out is their becoming distorted in shape, such distortion being the result of lamination. Now this effect may be produced either from defective shape, or from want of strength in the material itself to bear the superincumbent load. In regard to the usual T headed rail, the impression very generally prevails that the shape is in

fault; and it may very readily be imagined that a rail of this make, as shown in Fig. 4, Drawing 1, will assume the shape represented in Fig. 5, and gradually grow more distorted, from the pressure bending down the overhanging portions of the top table, without of necessity proving any motion to have taken place from absolute crushing. But bridge rails are found not to wear uniformly down, as they should do if no crushing took place; the upper corners of the rail turn outwards, and when the wearing part of the rail has been rolled or crushed out sideways, the centre part of the top is driven downwards, and the sides are turned completely over. The commencement of this process is represented in Fig. 7, the correct section being given in Fig. 6.

These observations would seem to confirm the conjecture previously hazarded, that under the weights now given to the engines, and with the limited extent of the tyre in contact with the rail in section, the rails themselves are gradually crushing; and remembering that the theoretical line of contact of the tyre on the rail in section must in all cases become a surface of greater or less extent, this effect is more to be attributed to engines with small-sized wheels used for goods traffic, than to the weight or speed of engines for express traffic, whose wheels are so much larger in diameter. And could the matter be investigated, it would be found that the rails suffered more from the passage of goods or mineral trains, than from that of passenger trains at whatever speed.

On the preservation of the perishable parts it would be beyond our limits to enter. Payne's process certainly has some effect in rendering the timber uninflammable, and therefore possesses advantage in the case of timber viaducts or the planking of bridges. Saturating the timber with creosote, as adopted by Mr. Bethell, has produced very satisfactory results in preserving the timber from dry rot or decay.

The length to which this paper has extended will prevent more than a very cursory description of a permanent way which would embody the more desirable features of efficiency and stability.

Drawing 2, Figs. 1 and 2, shows a wide double T rail, presenting a fair bearing surface to the tyre of from 2 inches to 2½ inches, and possessing considerable amount of side stiffness, being in depth 4 inches and in width 3½ inches, and weighing about 100 lbs. per yard.

The rail is secured by chairs to a longitudinal timber, 11 inches by 5½ inches, the chairs being sunk into the timber till the bottom surface of the rail is in contact with the top of the timber, along which a slight groove is cut, of such a shape that the rail shall bear harder on the outside edges of the groove than in the centre. Beneath the longitudinal timbers are sleep-

ers of triangular section, placed immediately under the chairs, 2 feet 6 inches apart at the joints, and 4 feet in the centre of the lengths of rail, these last being supposed in lengths of 17 feet. The sleepers are cut out of 10-inch balk, and retain the road in gauge whilst presenting an additional amount of bearing surface on the ballast, and admit of being packed without much removal of the ballast. In fact, these sleepers offer peculiar advantages for this mode of construction, although any others might be used. The chairs are secured through the longitudinal timbers to the cross sleepers by hardwood tree-nails, the holes in the longitudinal timbers being bored slightly larger than those in the cross sleepers to prevent the timbers from splitting. The rails may of course be manufactured in such lengths as may be most convenient, and the cross sleepers distributed accordingly; and it may be found that the sleepers may be placed at wider intervals. The longitudinal timbers are to be secured at the ends by a common half lap joint, this joint to be always on one of the middle sleepers, and not under the joint of the rail.

A modification of this road is shown in Figs. 3 and 4, Drawing 2, in which a longitudinal timber 12 by 4 inches is used, and the chairs are not let in to the timber, but a saddle is introduced between the chairs. The chairs, rail, saddle, &c., are shown full size in Drawing 3.

The rails may be secured to the chairs by either a hardwood or a wrought-iron key. The latter is more efficient, as it is not affected by wet or dry, and it prevents the rails from driving forward in the chairs. The wrought-iron keys are more costly; but as in this case they are composed merely of short lengths of iron tube, the difference in expense would not be considerable.

There is a difficulty in replacing the chairs, which will readily be seen by the members; but in practice this may not be found a very serious objection.

The CHAIRMAN moved that the thanks of the meeting be voted to Mr. Hoby for his interesting paper; and the motion was passed.

The CHAIRMAN observed that it was an important subject for consideration; the main question seemed to be, whether the surface of the rails was actually suffering from the crushing action that Mr. Hoby spoke of. It looked almost as if they had reached the limit of their powers, when they began to crush the material.

Mr. McConnell thought that a greater breadth of bearing surface of the rails would not be found to yield the advantage anticipated by Mr. Hoby; as it was so difficult to keep the bearing of the wheels in a straight line, and extending over the whole surface of the rails.

Mr. Woodhouse remarked that the rail proposed appeared to him rather shallow for the purpose, being only 4 inches deep.

Mr. McConnell said he should be afraid that the rail would deflect between the saddles when a heavy weight passed over.

The Chairman observed that the rail was very considerably increased in thickness laterally, and appeared a strong rail; but it must be remembered that the strength was diminished in proportion to the square of the depth. He did not attach so much importance as the writer of the paper appeared to do to the fact of the permanent way having deteriorated more rapidly in the last three or four years than previously. It was certain that on the older railways, which had been at work for 13 or 14 years, the deterioration of the rails had been much more rapid during the last three years of the time than during the first three years; but he thought the wear and tear of the present rails had been much overrated. It must be remembered that the present heavy engines had been increasing in weight, whilst the rails had been getting older and more worn; and he believed that the weight of the present engines had got pretty nearly, if not quite, to the feasible limit.

Mr. Woodhouse remarked there was an objection to the proposed plan, that broken chairs could not be replaced without taking the rail out, which would be very objectionable.

The Chairman observed it would certainly be a serious objection if the rail had to be taken out in order to replace a broken chair; all practical men were averse to it. He thought the lip on the inner side of the saddles might be dispensed with, which would allow them to be changed without disturbing the rail.

The CHAIRMAN announced that the Committee appointed to open the Ballot Lists reported that the following New Members were elected:—

MEMBERS.

GEORGE DAWES, . . .	Newcastle-under-Lyne.
EDWARD JOHN DENT, . .	London.
EDWARD ELWELL, JUN., . .	Wednesbury.
JOHN CURPHEY FORSYTH, .	Stoke-upon-Trent.
THOMAS FORSYTH, . . .	Wolverton.
JOHN MCCONOCHIE, . .	Liverpool.
THOMAS TIMMIS SMITH, . .	Nottingham.
JOSEPH TURTON, . . .	Sheffield.
THOMAS BURDETT TURTON, .	Sheffield.

HONORARY MEMBER.

JAMES BOYD THOMSON, . .	Glasgow.

The consideration of the paper by Mr. Ramsbottom, of Manchester, on an improved Locomotive Boiler, was adjourned to the next meeting.

The CHAIRMAN announced that some further particulars had been received from Mr. John Jones, of Bristol, respecting the Cambrian Engine; and laid the communication before the meeting for the reference of the Members.

The CHAIRMAN then said the business of the meeting was concluded, and he begged to thank the Members for their attendance, and hoped that at every fresh meeting they would do him the honour to attend as numerously as possible.

A vote of thanks to the Chairman was moved by Mr. Mc Connell, and passed; and the proceedings terminated.

INSTITUTION

OF

MECHANICAL ENGINEERS.

REPORT OF THE

PROCEEDINGS

AT THE

GENERAL MEETING,

HELD IN BIRMINGHAM, ON 25TH JULY, 1849.

CHARLES BEYER, ESQ., V.P.,

IN THE CHAIR.

BIRMINGHAM:
BENJAMIN HUNT AND SONS, 75, HIGH STREET.

1849.

PROCEEDINGS.

The usual GENERAL MEETING of the Members was held in the Theatre of the Philosophical Institution, Cannon Street, Birmingham, on Wednesday, the 25th July, 1849; CHARLES BEYER, Esq., Vice-President, in the Chair.

The CHAIRMAN opened the proceedings by stating that he was unexpectedly called upon to preside in consequence of the unavoidable absence of Mr. Robert Stephenson, their President, who was engaged in giving evidence before the House of Lords.

The minutes of the last General Meeting were read by the Secretary, and confirmed.

The CHAIRMAN announced that the following books, &c., had been presented to the Institution during the present year:

Eaton Hodgkinson on the Strength of Cast-Iron, by the Author.

Barlow on Railway Wheels, ditto.

Dent on the Aneroid Barometer, ditto.

Bourne on Indian River Navigation, ditto.

The Practical Mechanic's Journal, by the Editor.

The Mechanic's Magazine, ditto.

The Civil Engineer and Architect's Journal, ditto.

A Marble Bust of Mr. George Stephenson, by Mrs. John Joseph Bramah.

The following paper by Mr. Ramsbottom, of Manchester, was then read.

ON AN IMPROVED LOCOMOTIVE BOILER.

Without discussing the merits of the various arrangements and dispositions of the working parts of Locomotive Engines, the author of the present paper proposes to make a few observations respecting the most vital part of these machines, that upon which the satisfactory performance of all the details must necessarily depend, namely, the Boiler.

Before proceeding to the immediate subject of this paper, it is proposed to point out one or two objections to locomotive boilers as at present constructed, which experience has brought under the author's notice; and then to describe a form of boiler which appears to him in some degree calculated to remedy the defects which will be referred to.

It is scarcely necessary to observe that the absolute power of a Locomotive, or any other steam engine, is strictly proportioned to the quantity of steam which the boiler of such engine can produce in a given time; and chemists are generally agreed that the quantity of atmospheric air required, (or oxygen which is the supporter of combustion), as well as the quantity of fuel, is in direct proportion to the quantity of water evaporated; or in other words, to produce more steam, it is not only necessary to supply more fuel, but also more atmospheric air in proportion to the quantity of steam produced.

It is well known that some of the Locomotive Engines built at the present day have from two to three times as much heating surface as those built about eight or ten years ago, and consequently when performing a proportionately increased amount of duty, they require from two to three times the quantity of air forcing through the fire in the same time.

The working parts of these Engines have also been increased in dimensions; the cylinders from 12 inches to 15 and 16 inches diameter, the stroke from 16 inches to 20 and 24 inches, and the driving wheels from 4 feet 6 inches to 6 feet diameter, and in many cases even more.

Notwithstanding all these enlargements and improvements there are however two elements which have been but slightly changed; namely, *the diameter of the blast pipe*, and the diameter of the *cylindrical part of the boiler;* and as the whole of the steam (after having performed its office in the cylinders) is driven in a forcible jet up the chimney for the purpose of producing the necessary draught through the fire, and as the power required to produce this jet is so much taken from the gross power of the engine, it follows that the smaller the blast pipe is in proportion to the total heating surface of the boiler, the greater will be the resistance to the action of the piston, and the greater the loss of power on this account.

From observations made upon Engines under the author's immediate superintendence, it appears that whilst the heating surface of Locomotive boilers has been increased from 400 square feet (in the year 1842) to 987 square feet (in the year 1846), the blast pipe has not been in the slightest degree enlarged, but on the contrary in the latter case has been reduced in area in the proportion of 12½ to 8¼ square inches.

So that upon dividing the total heating surface or *area of production*, as it may be termed, by the size of the blast pipe, or *area of eduction*, (assumed as unity), the following very instructive results are obtained.

No. of Engine.	When built.	Aréa of Blast Pipe.	Heating Surface.
24	1842	1	4608
20	1842	1	5044
25	1845	1	7961
30	1846	1	12960

In the last case, then, it appears that the heating surface has been increased nearly *three-fold* in proportion to the size of the blast pipe, as compared with Engine No. 24 ; and the reason will be obvious when it is stated that the boiler No. 30 is only of the same diameter as the first named (No. 24), and consequently that the flue room, (which as a general rule will be as the square of the diameter of the boiler), has been but slightly increased, the extra heating surface having been mainly obtained by enlarging the fire-box, by putting in a mid-feather, and by increasing the length rather than the number of tubes.

It is not necessary to enquire how far the diameter of the cylinders may affect the size of the blast pipe, nor to ascertain the amount of power which the blast pipe absorbs, though it may be stated that experience proves it to range from 10 to 20 per cent. of the gross power of the engine, according to the number diameter and length of tubes, and also the speed of the engine. It may be remarked, however, that on the average a degree of exhaustion is required in the fire-box under ordinary circumstances equal to a column of water 4 inches in height, and the degree of exhaustion in the smoke-box must of course be greater than this by the resistance offered by the tubes to the passage of the heated gases from the fire-box to the smoke-box.

From experiments made about 2½ years ago upon an Engine with a total heating surface of 987 feet, carrying 147 tubes of 1¾ inch external diameter and 13 feet 10 inches long, the author found that the latter force was at all velocities *three times* as great as the former; or in other words, that 66 per cent. of the total force of the blast was required to overcome the resistance offered by the tubes to the passage of the heated gases, leaving 33 per cent. only to operate upon the fuel; and it is this evil which results from the comparatively limited flue area of the boilers as at present constructed, to which attention is now more particularly called, and which it is proposed to remedy in the manner now to be explained.

From what has been said it will readily be inferred that there is some difficulty in materially increasing the power of Locomotive Engines, as the necessary amount of heating surface cannot be obtained without increasing the diameter or the length of the boiler, or making it oval, to all of which plans there are some objections; but by the method now proposed it will be easy to enlarge both the fire-box and tube surface from 35 to 40 per cent., without increasing either the diameter of the boiler or its length, as will be now shewn.

It is proposed to construct the copper fire-box with an arched roof, the top of which shall be nearly as high as the top of the cylindrical part of the boiler, as shewn in the Drawing, Fig. 1, which represents a transverse section through the fire-box. This box may of course be made any length without sensibly reducing the strength of the roof, and will require none of the stay-bars which are so essential to the security of the flat-roofed box, and which for a moderate sized engine weigh not less than 400 lbs.

With such a box the whole of the cylindrical part of the boiler can be filled with tubes, and of course the whole of the longitudinal stays be removed; and in the present instance there are 225 tubes of 2 inches external diameter, the shell of the boiler being 3 feet 8 inches diameter and 10 feet long; the total heating surface of the fire-box is 80 feet, and of the tubes 1177 feet, making a total heating surface of 1257 feet.

Such an arrangement involves the necessity of keeping the boiler full of water, and it is therefore requisite that a separate steam chamber should be provided. This, as will be perceived from the Drawing, consists of a cylinder which is 13 feet long and 20 inches diameter, fixed over and parallel to the cylindrical part of the boiler, or, as it may now be termed, the generator. This tube, which has a cubic capacity of 28½ feet, is connected at each end with the generator, as shewn in the Drawing at A B, Fig. 2, which represents a longitudinal section of the boiler. It is proposed that the water shall occupy about one-fourth of the capacity of this tube, leaving a clear space of say of 21 cubic feet for steam; this is rather more steam-room than most modern boilers possess, and for reasons which are afterwards mentioned, the author thinks it will be sufficient, although it may readily be increased by slightly enlarging the diameter of the steam chamber, which as at present shewn, is not so high as the ordinary steam dome by about 12 inches.

It has been proved experimentally by Mr. Robert Stephenson that the generative power of the copper fire-box is three times as great per

unit of surface as that of the tubes; and independent of this authority, Locomotive Engineers are generally agreed that the great bulk of the steam generated in a Locomotive boiler is formed upon the surface of the copper fire-box and the first 18 or 20 inches length of the tubes. As the whole of the steam has to rise through the body of the water, with which it is for the time mechanically mixed, and as the specific gravity of these mixed fluids will be much less than the comparatively *un*mixed water at the smoke-box end of the boiler, it follows that there will be a brisk circulation through the generator and steam chamber, in the direction indicated by the arrows upon the Drawing. The mixed steam and water will be driven into the upper vessel, and will there be effectually separated; the former passing off to the cylinders by the longitudinal pipe C D, Fig. 2, which has a number of small holes upon its upper surface, and the latter running again into the generator through the vertical connection at the front end, and thus keeping up the circulation.

That the specific gravity of the mixed steam and water at the fire-box end is often reduced to at least one-half that of water alone, is proved by the fact that the water guage will frequently show a downward current through the glass tube, even though the circulating fluids be one half water and one half steam, shewing as it does that the column of the mixed fluids (F G, Fig. 4) in the boiler is specifically lighter than the column H I in the glass guage; and from this fact it is also evident that this great expansion is confined to the water in the vicinity of the fire-box, since if it extended to the whole mass, the boiler would not contain the requisite quantity.

From the circumstance that no bubble of steam can rise into the steam chamber between the points marked A and B, Fig. 2, it is concluded that this boiler will not be so liable to prime as the common one, and therefore that the steam chamber as shewn is sufficiently large. As to the water surface, which in this boiler it may be objected is smaller than in others, it is conceived that the great facilities this boiler will give to the engineer for raising steam, will leave him comparatively at liberty to put in water when and where he chooses, and consequently that but little difficulty need be apprehended on this point. It is evident however that the objection may be fully met by constructing the outer fire-box with a pyramidical roof in the way so common.

In conclusion, the author would express his conviction that this boiler, combining as it does a great increase of heating surface, *and corresponding increase of flue area,* with a relative diminution of bulk and weight, and great simplicity of construction, is calculated to remove

some of the difficulties experienced by Locomotive Engineers, and to promote the best interests of the Railway world in general.

The CHAIRMAN said, that in the unavoidable absence of Mr. Ramsbottom, he would observe that his object in the foregoing paper was to obtain a considerably larger area of flue-room than in the present locomotive boilers, and to make a boiler of a large heating-surface with less weight.

Mr. SLATE was of opinion that for the weight the engine carried, it would have a considerably greater effective heating-surface than any previous form of boiler; but he thought the boiler would have as great a tendency to prime as any other.

Mr. COWPER was also of opinion there would be a great tendency to prime in the proposed boiler; the surface from which the steam had to rise was the entire surface of the fire-box and tubes, and all the steam had to pass through the two openings into the steam-chamber, and it appeared to him the water would be carried up there in a complete state of froth.

Mr. MCCONNELL, while agreeing to a certain extent as to the liability of the boiler to prime, thought it might be obviated by having a more continuous communication between the generator and the steam-chamber; perhaps the steam-chamber could be fixed close upon the top of the generator, and a continuous longitudinal opening be made, communicating between them throughout their entire length. He thought the proposition of Mr. Ramsbottom was a very good one, as it was a received opinion that the proportion of the flue-room to the fire-grate surface could not be too large, supposing that full advantage was taken of the flue surface before the heated air reached the chimney. Whether long tubes or short tubes as applied to locomotives were most advantageous, was a question not yet decided, and he thought they had scarcely data enough to determine as to the advantage of long tubes on the ground of economy. It was a very important matter to determine what length of tubes was most advantageous for use in proportion to the area of the fire-grate.

Mr. C. COWPER was not aware whether there was any authority respecting the proportionate heating power of the tubes and the fire-box, besides the experiment of Mr. Stephenson alluded to in the paper.

Mr. McConnell remarked, that it appeared from experiments made by Mr. Stephenson and Mr. Beyer, that a very considerable heat was lost in the smoke-box even at the end of the longest tubes that were used; and he thought that the air in the centre of the tubes might have a considerably higher temperature than the air at the sides of the tubes, and that much of the heat might be carried through by a stream of air like a solid bar in the centre of each tube, without ever coming in contact with the sides of the tube, and consequently without being communicated to the water of the boiler. He had been informed that it was found to be a useful practice in marine and stationary boilers, to create a disturbance in the currents of air passing through the flues, for the purpose of mixing up the particles as much as possible; and a similar advantage might probably be obtained by mixing the air in the tubes of locomotive boilers.

Mr. Gibbons said, he had observed a similar advantage from mixing the particles of air in heating the air for his blast furnaces near Dudley; the pipes through which the air was passed for the purpose of heating it were bent like a syphon, so as to cause all the particles of air to come in contact with the sides of the pipes, and the air was found to be heated much more efficiently by these bent pipes than by straight pipes.

Mr. Allan said, he had tried an engine with a ½ inch iron rod fixed in the centre of each tube; the rods were as long as the tubes and supported at intervals by short projecting pins to hold them in the centre of the tubes. The engine had been worked with them for some time between Birmingham and Liverpool, but no difference was found in the working and consumption of coke, as compared with the same engine doing the same work without the rods in the tubes; the result was found to be exactly the same in both cases.

Mr. C. Cowper remarked, that the rods in the tubes would have the effect of contracting considerably the flue area, and increasing proportionately the amount of power requisite to draw the air through the tubes, and consequently the rods in the tubes would cause a loss of power to the engine from the increased resistance to the blast. He thought therefore the rods must have caused an equal amount of gain to neutralize this loss, by bring-

ing the air into more effective contact with the sides of the tubes, as the result showed no loss on the whole.

Mr. McConnell thought it was certain at least that the use of the rods did no harm; and it must either be considered that there was no advantage in a large flue area, or that there was considerable advantage in mixing the air in passing through the tubes.

Mr. Slate was of opinion, that even on the ground of economy a large number of tubes was advisable, because with the violent and frequent action of the pieces of coke the tubes were soon worn out; whereas by increasing the number of tubes the velocity of the draught would be diminished, and the tubes would be less worn and would last longer.

The Chairman remarked, that the larger the area of the flue, the better it was for the engine, as it must offer less resistance to the blast-pipe; but he was not certain what this resistance actually amounted to.

Mr. Cowper said, that Mr. Daniel Gooch had found from his indicator cards, that the resistance of the blast-pipe amounted to 11 or 12 lbs. per square inch, at a moderate velocity of about 30 miles an hour.

Mr. McConnell observed, that as a certain quantity of heated air had to be conveyed from the fire-box to the chimney, and a certain area of heating surface was also required, there would be an important reduction effected in the resistance of the blast-pipe by increasing the number of tubes, so as to increase the area of passage and reduce the length of the tubes, diminishing proportionately the resistance of the air passing through the tubes.

The Chairman said, he was present when the experiments were tried that were mentioned by Mr. Ramsbottom, to ascertain the difference between the degree of exhaustion in the smoke-box and in the fire-box; the experiments were tried with a long boiler engine, and a glass water guage was fitted into the smoke-box and another into the fire-box. The degree of exhaustion in the smoke-box averaged three times as great as that in the fire-box, and this proportion was found to be nearly the same at all velocities; the greatest amount of exhaustion observed in the smoke-

box supported a column of water 13 inches high. He thought that the whole resistance of the blast-pipe and the back pressure in the cylinder, did not amount to more than 15 per cent of the power of the engine.

Mr. SLATE remarked, that assuming it to be 15 per cent, it followed that 10 per cent of the whole power of the engine was absorbed by the friction of the air in passing through the tubes, as the exhaustion in the smoke-box was three times as great as in the fire-box; or one-third only of the pressure of the blast was effectively acting in the fire-box.

Mr. McCONNELL thought it was an important subject for investigation, to ascertain the actual power lost by the resistance of blast-pipes of different sizes, and under the different circumstances of size and number of tubes. In his own practice he had found that small tubes and many of them produced the best effect; the limit in reducing the size of the tubes was their stopping up with pieces of coke whilst working.

The CHAIRMAN said, he thought there was some advantage in the form of boiler proposed by Mr. Ramsbottom, and that amongst the various modifications that had been proposed of the locomotive boiler there was not one that was so likely to be useful.

A vote of thanks was passed to Mr. Ramsbottom for his paper.

The following paper by Mr. Benjamin Gibbons, of Shut End House, near Dudley, was then read.

ON A PNEUMATIC LIFT.

The Pneumatic Lift described in the present paper is employed to raise the ore coal and limestone for charging four smelting furnaces at Corbyn's Hall New Furnaces, near Dudley.

In some districts the levels of the ground admit of the furnaces being charged by wheeling the materials on a level platform from higher ground to the top of the furnaces, but in general these have to be raised by machinery to the level of the top of the furnaces, the height raised being about 40 to 50 feet. The usual plan of raising the materials is by an inclined plane, which rises from the ground to the top of the furnaces at an angle of about 30 degrees; there are two lines of railway upon it, and a travelling platform on each line, drawn up by a steam

engine by means of a chain passing over a pulley at the top of the inclined plane. The two platforms balance one another, one of them descending while the other ascends, and the top of each platform is made horizontal and works level with the ground at the bottom and with the stage at the top of the furnaces, so that the barrows of materials are readily wheeled on and off the platforms; several barrows are carried by each platform. A rack is fixed on the inclined plane along the centre of each line of railway, and a catch is fixed on the moving platform which falls into the teeth of the rack in ascending, for the purpose of stopping the platform and preventing an accident in the case of the chain breaking; but the use of this catch is found to be inconvenient in practice, and is generally omitted. There is a difficulty in stopping the platform at the required level, and the inclined plane is objectionable from the space which it occupies and the expense of its construction.

Where the inclined plane cannot be employed, the power of the steam engine is not employed directly to draw up the materials vertically by a chain, because of the difficulty in working it conveniently and safely, to stop the platform at the correct level for wheeling the barrows on and off, and prevent the risk of serious accident by the chain breaking, particularly in the night work. At some Iron Works an endless chain is used for this purpose with a series of buckets fixed upon it, which are filled with the materials at the bottom and empty themselves into the furnace by turning over at the top. This lift is not suitable for supplying more than one furnace; and when there are more than one furnace it is most advantageous to employ a lift that will take up the materials in the barrows, ready for wheeling at the top to the different furnaces.

Another plan for lifting vertically is by means of a water balance; the platform on which the barrows of materials are raised is suspended by a chain passing over a pulley at the top, and a bucket is attached to the other end of the chain; the platform in descending draws up the empty bucket, and when the platform is loaded the bucket is filled with water until it overbalances the loaded platform and draws it up. There is an important objection to this plan, that the bucket descends with an accelerated velocity, and a friction break has to be used to check the velocity to prevent a violent concussion on stopping its momentum at the end of the descent; this causes a risk of accident from breakage of the chains, and the friction break is also liable to derangement and expensive repairs.

At the Level Iron Works near Dudley an instance occurred where a vertical lift had to be introduced in consequence of the furnaces being

raised 16 feet in height; there were two furnaces, originally 34 feet high and raised to 50 feet high, and at the original height the materials were wheeled on the level to the top of the furnaces. When the height of the furnaces was increased the materials were required to be raised 16 feet, and a vertical lift was necessary in consequence of the situation being so much confined by a canal as to prevent the adoption of an inclined plane. For this purpose the author of the present paper constructed a Pneumatic Lift, worked by the pressure of the air from the blowing engine that supplied the blast for the furnaces. This lift was designed with the object of avoiding the objections to the plans of vertical lifting previously in use, and obtaining a safer and more economical application of power.

This Pneumatic Lift consisted of a heavy cast-iron cylinder, 4 feet 4 inches diameter inside, closed at the top, and inverted in a well filled with water, in which it was free to slide up and down like a gasometer; this cylinder was suspended from the top by a chain fastened to the circumference of a pulley which was fixed on a horizontal shaft above the level of the top of the furnaces. A pipe from the air-main was carried down the well and turned up inside the cylinder, rising above the surface of the water, and when the blast was let into the cylinder through this pipe the cylinder was raised in the water by the pressure of the compressed air against the top; this pressure was about 2 lbs. per square inch. A platform for raising the barrows of materials was suspended by a chain from another pulley on the same shaft as the former pulley, and the platform was guided in its ascent by vertical framing. The cylinder was heavy enough to draw up the platform with the load upon it by descending into the water when the blast was withdrawn; and the empty platform was lowered by admitting the blast into the cylinder and thus raising it. The cylinder was lowered again by opening a valve which let out the compressed air, and its velocity of descent was regulated by opening this valve more or less. The velocity of the platform both in rising and falling was completely under command, by regulating the opening of the valves for admitting or letting out the compressed air, and the velocity was gradually checked towards the end of each stroke with certainty and ease, so as always to stop the platform without concussion. The height to which the cylinder was raised was only 5 feet, and the two pulleys were made of different diameters so as to raise the platform 16 feet; the load raised upon the platform was about half a ton. This Pneumatic Lift has now been in constant work for 39 years, and has worked quite satisfactorily during the whole time; it has not required any repairs except renewal of the

chains and repair of the rubbing parts. An accident happened once by the chain breaking whilst lifting, and the platform fell about 5 feet, causing a shock to the man going up with it, but no injury was done to the machinery.

An improvement on this Pneumatic Lift was made by the author of the present paper, in constructing a lift on a considerably larger scale at the Corbyn's Hall New Furnaces; this is shewn in the accompanying Drawing, and was constructed at the time of building the furnaces. The height to which the materials have to be raised is 44 feet 6 inches, and the present plan was designed to prevent the risk of an accident occurring through the breaking of a chain. There are four furnaces supplied by this lift, which is fixed between two of them, and the four furnaces are connected on the same level by the staging at the top, on which the barrows of materials are wheeled from the platform of the lift.

In this lift the platform for raising the barrows of materials is fixed on the top of the air cylinder, and it is raised by the pressure of the blast, the action being the reverse of the former plan. In the accompanying Drawing the lift is shewn at the highest position in Fig. 1, and at the lowest position in Fig. 2. A is the Air Cylinder, which is 5 feet 6 inches diameter and 51 feet 6 inches long, constructed of riveted wrought-iron plates averaging $\frac{1}{4}$ inch thick, the plates being $\frac{5}{16}$ inch thick in the lower part and $\frac{3}{16}$ in the upper part; the cylinder is closed at the top and open at the bottom, and has a Throttle Valve B, 8 inches diameter, in the centre of the top, which is opened by pressing down the Foot Lever C fixed upon the platform.

D is the Platform on which the materials are raised; it consists of planking carried on timber bearers, which rest upon the edge of the cylinder top, and upon four wrought-iron Brackets E E carried out diagonally from the cylinder to steady the platform, and fixed to two hoops passing round the cylinder.

F F are four timber Guides placed at the corners of the platform, and connected at top to the level stage G G upon which the barrows of materials are wheeled to the mouth of the furnace H. These guides are faced with angle-iron on the inner edge, and a corresponding angle-iron is fixed in a notch at each corner of the Platform D, to slide easily up the guides; the height that the platform rises is 44 feet 6 inches.

Four cast-iron Balance Weights I I are suspended outside the Guides F F by chains which pass over the Pulleys K K in the top framing, and are attached to the four corners of the platform D. These four balance weights weigh about $6\frac{1}{2}$ tons, and the air-cylinder and platform together weigh 7 tons; leaving an unbalanced weight of about $\frac{1}{2}$ ton to bring down the air-cylinder and empty the platform.

The air-cylinder A descends into a Well L L which is filled with water to the level M, and it is guided by four Rollers N N 6 inches long and 7 inches diameter, each of which works against a strip of bar-iron riveted on the cylinder, 4 inches wide and the whole length of the cylinder. At the bottom of the well a foundation of timber O is fixed, to form a stop for the cylinder in descending, and the cylinder rests upon the timber when at the lowest position by a ring of angle-iron riveted round the bottom edge. The cylinder is stopped on rising to the top by a wood block fixed on each of the four guide-posts F F, which stop the platform at the level of the top stage G G.

P is a cast-iron Pipe 7 inches inside diameter, which conveys the compressed air from the air-main, and the Pipe Q of the same size carries it into the cylinder, passing down to the bottom of the well between the cylinder and the side of the well, and rising up the centre of the cylinder; the end of the pipe at R is open and stands above the level of the water.

The Valve S regulates the admission of the compressed air into the cylinder when the platform is raised, and also lets out the air from the cylinder when it is lowered. This valve consists of a plug or deep piston sliding in a vertical bored cylinder of the same diameter as the air pipe, which is closed at the top and open at the bottom. When the plug is in the lowest position as shewn in Fig. 1, it closes the bottom of the cylinder and the communication is opened betwen the pipes P and Q, and the compressed air passes into the Air Cylinder A, and raises it with the Platform D, by the pressure of the air upon the top of the cylinder and upon the surface of the water; the pressure of the compressed air is 2½ lbs. per square inch, and the water is depressed inside the cylinder to T and raised to U outside the cylinder, making a difference of level of 5 feet 4 inches. When the platform is required to be lowered, the Plug Valve S is drawn up to the top as shewn in Fig. 2, closing the pipe P that admitted the compressed air, and leaving the pipe Q open to the external air to discharge the compressed air from the Cylinder A; this discharge is accelerated by opening the Escape Valve B at the top of the air-cylinder by means of the Foot Lever C.

The total pressure of the compressed air against the top of the air cylinder is 3½ tons; and deducting the unbalanced weight of the cylinder and platform ½ ton, this gives an available lifting power of 3 tons. The load of materials raised varies according to the working of the furnaces, and the average load of materials raised each time is 1¼ tons, exclusive of the barrows and men, or about 2 tons gross weight. The lift is raised 16 times per hour during 20 hours in each day of 24 hours, or

once in $3\frac{1}{2}$ minutes; and the total weight of materials raised each day is about 500 tons. The time of raising the platform from opening the inlet valve to reaching the top is from 50 to 70 seconds, according to the load in regular work; and the time of lowering the platform is from 30 to 50 seconds according to the degree of opening of the escape valve on the top of the air cylinder; the empty platform can be raised in 45 seconds, and lowered in 25 seconds, with the present size of apertures.

In raising the platform the inlet valve is kept full open until the platform arrives at 14 inches distance from the top, when it catches a lever which gradually draws up the plug of the inlet valve, so far as nearly to close the pipe leading to the air cylinder; this checks the moving power and causes the velocity of the platform to be so much retarded by the time it arrives at the top, that the platform stops dead against the wood blocks without any concussion being felt. The platform is held firmly up to these stops by the pressure of the air as long as may be required, without any recoil, and without requiring any catches to hold the platform, as it cannot descend in the least unless the air is allowed to escape from the cylinder, and the supply from the air pipe keeps it full in the case of any leakage taking place. When the platform is raised empty, a wood block turning on a pivot is slipped by the foot under the lever that closes the inlet valve, so as to begin closing the valve sooner; this is adjusted according to the velocity of the ascent of the platform, and regulates the lifting power so as to prevent any concussion on stopping at the top of the ascent.

When the platform arrives at the top, the men who go up with the barrows, wheel them off to discharge the materials into the several furnaces; and as soon as the empty barrows are brought back, the platform is lowered by drawing up the plug of the inlet valve to the top, which shuts off entirely the supply of compressed air, and opens the exit below the plug for the air in the cylinder to escape. This is done by the men on the platform at the top by means of a rod from the valve carried up the framing; and the escape valve on the top of the cylinder is then opened and kept open till the platform is near the bottom, when it is closed and the velocity of the platform is so much checked before stopping that scarcely any concussion is felt at stopping; it can easily be stopped without any concussion.

The velocity of the platform is also gradually checked in descending by the gradual immersion of the cylinder in the water, which reduces the unbalanced weight of the cylinder. The total loss of weight of the cylinder when at its greatest immersion in the water is $\frac{1}{2}$ ton, which reduces the effective unbalanced weight of the cylinder and platform

from ⅓ ton to nothing; but the weight of the four chains amounting to ⅛ ton is added to the balance weights at the beginning of the descent, and is transferred to the platform at the end of the descent, and the result is that the moving power causing the descent of the platform is reduced ¼ ton during the descent, being about ⅜ ton at starting and ⅛ ton at stopping; this moving power can be altered as required, by altering the balance weights.

This lift was originally constructed to work only two furnaces, and the air pipe was only 5 inches inside diameter, and the time of raising the platform was usually 140 seconds; when the other two furnaces were added it became necessary to add a second air pipe of the same size, for the purpose of working the lift twice as fast; one pipe only is shewn in the accompanying Drawing, equal in area to the two actually employed. When the lift was constructed it was found that the well could not be made sufficiently water-tight, on account of a slight disturbance in the strata from the getting of the neighbouring mine, and an outer cylinder of similar construction to the air cylinder, was consequently sunk into the well; this outer cylinder having a close bottom, and holds the water in which the air cylinder works, like the tank of a gasometer.

The quantity of air blown into the cylinder each time of raising it is 1128 cubic feet, and the total quantity per day of 24 hours is 360,960 cubic feet, or about 12 tons weight of air; the total quantity of air blown by the blast engines is 16,185 cubic feet per minute, and 23,306,400 cubic feet or about 780 tons weight of air per day of 24 hours. The proportion of the total blast that is used by the lift is therefore as 12 tons to 780 tons, or $\frac{1}{65}$ of the whole, and consequently $\frac{1}{65}$ part of the total power of the blowing engines is employed in working the lift; there are two blowing engines employed. The pressure of the blast is 2½ lbs. per square inch, and the total engine power is consequently 165 horse power; and the air consumed by the lift being $\frac{1}{65}$ of the total blast, it follows that $\frac{1}{65}$ of 165, or 2½ horse power, is the power that is actually employed in working the lift; this power being a constant power acting during the whole day instead of acting merely at the times when the lift is rising. The actual power required to elevate the lift, with the average gross load of 2 tons on the platform, or 2¼ tons total weight, including the average unbalanced weight of the cylinder and platform, raised 44 feet 6 inches in 70 seconds, is 6 horse power; the greatest power employed being 3½ tons raised that height in 70 seconds, which amounts to 9 horse power, and the least is ¼ ton raised in 45 seconds amounting to 1 horse power. Thus it appears that the work of 6 horse power occurring at intervals, is performed by a power of 2½ horse power constantly acting.

The total consumption of coal-slack by the blowing engines is about 13 tons per day of 24 hours, consequently the expense of working the lift is $\frac{1}{65}$ part of this, or 4 cwt. of coal-slack per day, costing about 5*d.* per day; and as this lift raises 500 tons of materials per day, it follows that 100 tons are raised 44 feet 6 inches high for 1*d.*, or 4450 tons are raised 1 foot high for 1*d.* The quantity of air required to fill the cylinder of the lift is 1128 cubic feet, and the total contents of the blowing cylinders for one double stroke is 1056 cubic feet; consequently an increase in the rate of the engines of one stroke per minute is sufficient to raise the lift in 70 seconds, without diminishing the supply of air for the blast of the furnaces.

These two circumstances cause an important economy in working this Pneumatic Lift; a small power constantly acting is sufficient to do the work, and the sudden application of this power concentrated into a short time causes but a small increase in the rate of the engine. The total cost of this lift was about £500; and the cost of an inclined plane lift, including the engine for working it, would be about double that amount.

This Pneumatic Lift has been in constant work for the last 9 years, and no accident or stoppage has occurred with it, except that the chain of one of the balance weights broke once; the platform stopped with a very trifling fall, and was held in its position by the pressure of the air; no damage was caused, and the lift was got to work again within an hour's time. The only repairs that have been required since it commenced working, are the renewal of the chains of the balance weights and repair of the pulley bearings; the set of chains can be taken off and replaced whilst the lift is standing during the dinner hour, without causing any delay to the work. This is an important advantage, as it is essential to ensure a continued supply of materials to the furnaces, and to avoid any risk of stoppage for repair of the lifting machinery.

The platform in this Pneumatic Lift cannot fall quicker than the time in which the whole body of air can escape, amounting to 1128 cubic feet; and the greatest leakage that can arise from an injury of the cylinder cannot let it down so rapidly as to cause any damage. The load is supported by an air cushion during the whole time of its ascent, instead of depending on chains or racks, which prevents any risk of its falling. The complete control over the motion of the platform that is given by the air valve which regulates the entrance and exit of the air, gives the means of checking, stopping, or reversing the motion at any part of the stroke; and it prevents any concussion at the ends of the stroke, although the lift has a quick action, and is stopped dead at each

end of the stroke at the exact level required. The friction of the lift is very small, as the cylinder works through a water joint; and in consequence of the low pressure at which it is worked the loss at any leak is very small, and the strain upon the joints is much diminished.

This Pneumatic Lift is of course applied most economically and conveniently in the case of Blast Furnaces, where the compressed air can be obtained very economically and without additional machinery; but it is probable that its application may be extended advantageously to several other cases, such as raising Railway waggons, or even Railway trains, discharging vessels at quays, and various other purposes, and it possesses several advantages which make it deserving of consideration. The low pressure at which it is worked causes great simplicity and economy in the construction and working, the loss at leaks being reduced, and the joints easier kept in order; and the friction is very small as the cylinder works through a water joint. Where the lift is not required to be always working, but only to be worked at intervals, a further economy could probably be effected by employing a reservoir for the compressed air, to accumulate power during the time that the lift is not required to work, and thus reduce the size of engine requisite for the work; a large capacity of reservoir could be constructed at a moderate expense, on account of the low pressure upon it. It may be mentioned that at the Corbyn's Hall New Furnaces the reservoir of compressed air contains 5000 cubic feet at the pressure of the blast, $2\frac{1}{4}$ lbs. per square inch, and consists of four wrought-iron cylinders from 6 to 8 feet diameter, constructed of riveted plates from $\frac{1}{8}$ to $\frac{3}{16}$ inch thick; and the cost would be about £3 per 100 cubic feet for air reservoirs of this construction.

Mr. Buckle observed, that he had frequently seen this lift at the works of Mr. Gibbons, and could bear testimony to its smooth and exact working and its uniform motion. He was of opinion it might be usefully applied to a variety of purposes, as it was undoubtedly the best description of lift that he was acquainted with for its present purpose.

The Chairman said, it appeared to him to be a very simple and efficient mode of raising the materials.

Mr. Cochrane observed, that a similar lift was employed at his Iron Works, for which he had been indebted to Mr. Gibbons; it had proved entirely satisfactory, and there had never been any accident with it.

Mr. Gibbons remarked, that his object in bringing the lift

before the Institution, was to render it more generally useful; for in his opinion it might be advantageously applied to a great variety of purposes, more especially at railway stations and in the docks. It would be a great convenience for raising and lowering trucks, and for loading or discharging vessels; as the platform could be quickly raised or lowered to any exact level, and could be stopped at any point at pleasure without concussion, and held quite firm in the position without any danger of falling, as long as might be required.

Mr. Slate thought it was applicable to lifting railway waggons; and considered that a small blowing engine might be advantageously employed for the purpose, working at a much quicker rate than usual, even 700 feet per minute, like the pistons of locomotive engines; the leakage of the piston would then be of much less consequence.

Mr. Cowper suggested that steam might be available for the purpose of raising the lift where there was not a blowing engine at work; for although there would be a loss of steam by condensation on the surface of the water, that loss would be very small compared to the whole quantity of steam employed, as the surface of the water would become quickly heated by the steam, but the heat would only extend very slowly downwards in the water.

Mr. Gibbons remarked, that he considered there would be a difficulty in applying steam from the difficulty of keeping the joints steam-tight.

Mr. McConnell referred to the use of hydraulic cranes which had been introduced at some railway stations and other places; and observed that it appeared to involve the question of the relative cost and advantage of air and water as the means for communicating the power.

Mr. Gibbons observed, that the pistons necessarily used in hydraulic cranes were liable to get out of order, and were a source of expense and trouble, and there was also a considerable loss of power from friction, which was not the case in the pneumatic lift. He thought that by the latter plan a whole railway train might be raised a considerable height, without the motion being felt by the passengers.

A vote of thanks was passed to Mr. Gibbons for his communication.

The Secretary then read the following paper, by Mr. Fairbairn, of Manchester.

ON THE EXPANSIVE ACTION OF STEAM, AND A NEW CONSTRUCTION OF EXPANSION VALVES FOR CONDENSING STEAM ENGINES.

The innumerable attempts that have been made to improve the principle of the condensing Steam Engine since the days of its celebrated inventor Watt, have almost all of them proved failures, and have added little if anything to the claims, next to perfection, of that great man's ideas. It would be idle to speculate upon the various forms and constructions from that time to the present, which have been brought forward in aid of the original discovery of condensation in a separate vessel. All that has been done is neither more nor less than a confirmation of the sound views and enlarged conceptions of the talented author of a machine which has effected more revolutions and greater changes in the social system than probably all the victories and all the conquests that have been achieved since the first dawn of science upon civilized life.

It would be endless to trace the history of the successful and the unsuccessful attempts at improvement which for the last half century have presented themselves for public approval; suffice it to observe, that no improvement has been made upon the simple principle of the Steam Engine as left by Watt, and but few upon its mechanism. Among the latter may be enumerated the improvements in the construction and mode of working the Valves; and of these the D Valve by the late Mr. Murdock, and the use of Tappets as applied to the Conical Valves, appear the most prominent and the most deserving of attention.

In the construction of the parallel motion, the application of the Crank, the Governor, and the Sun and Planet motions, all of which have risen spontaneously from the mind of Watt, there is no improvement. The principles upon which all of them are founded have been repeatedly verified beyond the possibility of doubt, and their mechanism is at once so exceedingly simple and so ingeniously contrived as to limit every attempt at improvement in those parts of the Steam Engine. What appears to be the most extraordinary part of Mr. Watt's Engine is its perfect simplicity, and the little he has left to be accomplished by his successors.

It will be in the recollection of most persons conversant with the Steam Engine, that the hand gear for working the valves by the air-pump or plug-rod, gave a self-acting and continuous motion to the

machine; and the facility which these means afforded for moving the Engine in any direction and at any required velocity, gave it a degree of docility and power beyond the expectations of its most sanguine admirers.

For a considerable length of time the hand gear was the best and most effective mode of applying the motion of the Steam Engine to the Valves; subsequently the oscillating and revolving Tappets, fixed upon a shaft and driven by wheels or an eccentric, came into use, and by means of vertical rods communicated motion to the valves, and thus a similar effect was produced as by the hand gear; next came Mr. Murdock's D Valve and eccentric motion, which for simplicity has never yet been equalled. The D Valve, and the flat plate Valve, are nearly synonymous, with this difference only, that the D Valve presses with less force upon the face, and consequently works easier than the flat valve, which in every case is exposed to the full pressure of steam. It is true that means have been adopted to obviate this objection in large Engines, by a preparation on the back of the valve, which is made steam-tight, and by a communication with the condenser, a vacuum is formed over a proportionate area of surface, sufficient to equalize the pressure and admit an easy motion of the valve.

The expansive principle upon which Steam Engines are now worked, and the economy which this system has introduced in the expenditure of fuel, has effected considerable changes in the working of the Valves, and has rendered the D and plate Valves almost inadmissable for such a purpose. To the skill, ingenuity, and careful attention of the Cornish Engineers, we are indebted for many of the improvements connected with the use and application of expansive steam; and taking into account the high price of coals, and the urgent necessity of economy in those districts, which combined with a system of registry and encouragement held out by premiums as described by Mr. John Taylor, we may reasonably conclude that other parts of the kingdom have been greatly benefitted by the excellent examples set before them by the Cornish Miners and Engineers.

For a great number of years, and up to a recent period, the Economy of Steam and the working of the Steam Engine expansively, were but imperfectly understood in the manufacturing districts; and although the Cornish miner set an excellent example and exhibited a saving of more than one-half the fuel, there were nevertheless few if any attempts made to reduce what is now considered an extravagant expenditure in most if not the whole of our manufactories. But in fact the subject was never brought fairly home to the Millowners and Steam

Navigation Companies, until an equalization or reduction of profits directed attention to the saving attainable by a different system of operation.

Ten years ago the average or mean expenditure of coal per indicated horse power was computed at from 8 to 10 lbs. per horse power per hour, but now it is under 5 lbs. per horse power per hour in Engines that are worked expansively, and even then they are far below the duty of a well-regulated Cornish Engine, which averages from 2¼ to 5 lbs. per horse power per hour.

This difference in the consumption of coal may be attributed to two causes; first, the conditions under which the duty of the two Engines (that of the Cornish miner and the Manufacturer) are respectively performed. The first being chiefly employed in pumping water, has the benefit of alternate action in overcoming the inertia of a large mass of matter, which when once in motion is easier continued, for a definite time, than a continuous power of resistance, such as exhibited in Corn and Cotton Mills. Another cause is the greater care and attention which the Cornish man pays to his boilers, steam pipes, &c.; they are never left exposed, but are carefully wrapped up in warm jackets and well clothed, to prevent the escape of heat. Even at the present day, it is lamentable to see (in the Coal and Iron Districts) the great and extravagant waste that is continually going on, for want of a little considerate attention in this respect; the only excuse is the cheapness of the fuel—but that is not an excuse, for if one-half can be saved, and coal could be got at 1*s.* per ton, it is certainly desirable to save sixpence out of the shilling, when that can be accomplished at a trifling expense. But one of the chief, if not one of the most important reasons for the exercise of economy in fuel, is the reduction of profits on articles manufactured by power; under these circumstances, a saving in coal becomes a consideration of some importance, and to these reductions alone may be traced the powerful stimulus which of late years has been prevalent in that direction. The low rate of profit in manufacturing operations, and a desire to economise and reduce the cost of production to a minimum, has been of great value in its tendency to improvement in the economy and efficient use of fuel, and also to the use of high pressure steam and its expansive action when applied to the Steam Engine. In France and most other parts of the continent this system has been long in use, and although its effects as well as its economy have been long known in this country, it was only within the last few years that the benefits arising from it were appreciated. For a great number of years a strong prejudice existed against the use of

high pressure steam, and it required more than ordinary care in effecting the changes which have been introduced: it had to be done cautiously, almost insiduously, before it could be introduced. The author of this paper believes he was amongst the first in the Manufacturing Districts who pointed out the advantages of high pressure steam, when worked expansively, * and for many years he had to contend with the fears and the prejudices of the manufacturers, before the present system of economical working was adopted.

The first attempt was by improvement in the construction of Boilers, † and subsequently in the Valves of the Steam Engine, adapted to either low or high pressure steam when worked expansively; the latter of which it is the principal object of the present paper to develope.

The Expansive action of Steam has been variously estimated by different writers, but all seem to agree in opinion that a considerable saving is effected by that process. It therefore becomes a question of importance in a community whose very existence almost depends upon the Steam Engine, how to work it advantageously and at the least possible cost. The great variety of schemes and forms which have been adopted for the attainment of these objects have been exceedingly various, ingenious, and interesting; and the investigation of the different theories and applications that have been submitted for public approval, would form an exceedingly attractive if not a useful history of the various discoveries to which we are in a great measure indebted for the present improved construction of the Steam Engine.

The elastic force and expansive action of steam were well known to Mr. Watt and some of his immediate contemporaries and successors, such as Smeaton, Cartwright, Woolf, Trevithick, and others; but the fears entertained of explosion at that early period, and the difficulty of constructing vessels strong enough to contain high pressure steam, were probably the greatest drawbacks to its introduction. Woolf and Trevithick were probably among the first to grapple with this dangerous element; and the former in order to economise fuel introduced the Double-Cylinder Engine, whereby a great saving was effected by increasing the pressure of steam in the boiler, and allowing it to pass from one cylinder to another of three or four times the capacity, by which its volume was expanded, and by these means a saving was effected and an extra duty performed. If, for example, taking a Double-

* See Paper read before the Geological Society of Manchester in the year 1840, on the Economy of Fuel.

† See Report on the Prevention of Smoke and Economy of Fuel.—Transactions of the British Association, 1844.

Cylinder Engine, the high pressure cylinder being $\frac{1}{4}$ of the capacity of the cylinder from which the steam is condensed, there will be for one cylinder full of steam an expansion of four times its volume, this of course with a diminished pressure in the ratio of the capacities of the two cylinders. Comparing this with a similar process in a Single Cylinder equal in capacity to the two Cylinders, and fitted with a well-constructed apparatus, regulated so that only one-fifth of the contents of the cylinder (equal in capacity to the small cylinder on Woolf's plan) is filled with steam of equal density, and the remaining four-fifths (equal in capacity to the larger cylinder) is allowed for expansion, it is evident that the communication being thus suddenly cut off from the boiler after the piston has been urged through only one-fifth of the length of the stroke, the expansive force is then used in completing the remaining four-fifths of the stroke, and the result must be nearly the same as that obtained with the two cylinders on Woolf's plan. The advocates of Woolf's system however insist upon its superiority, not from the actual force given out, (which is rather in favour of the single cylinder than the double, in consequence of increased condensation in the steam passage between the two cylinders), but from the superior action and greater regularity of motion which in the former case is produced. To some extent this is the case, but not to any appreciable amount provided the Fly Wheel is well-proportioned to the pressure and power at which the Engine is worked. In the double Engines which are now in common use, that is, when two single Engines are coupled together with the cranks at right angles to one another, there is less occasion for a heavy fly wheel, as the effect of a large expansion is less felt, if not effectually neutralized. The results, therefore, of the Double-Cylinder Engine and the Single Engine working at equal rates of expansion, are virtually the same as regards power and economy of fuel, if the comparison be not in favour of the Single Engine.

Having come to the conclusion that the same duty can be performed by the single as by the compound Engine, and considering the important advantage of simplicity in mechanical construction, in opposition to complexity however ingeniously contrived, it becomes a question how to obtain an effective as well as a simple process for the attainment of that object.

The first attempt was by revolving Tappets, which had been long in use; these being formed and regulated in such a manner as to cut off the steam at such a point of the stroke, as to give the exact quantity of expansion required. These Tappets, to say the least, were from various reasons objectionable, as the weight of the vertical rods and the slowness

of motion prevented them from producing the desired effect. The Steam Valves could however be fixed so as to cut off the steam at the required point of the piston passage in the cylinder, but the motion is not effected with the velocity essential to an efficient process of expansive action. Other processes have been tried for working Steam Engines expansively besides those already noticed; amongst them may be noticed the equilibrium Valve, worked by double cams from the Crank Shaft. This method is generally used and adapted to the Marine and old Engines, but its application is seldom of much value unless the Engines and Boilers are capable of bearing a pressure of 15, lbs. to 20 lbs. on the square inch.

Another fault to which this description of Valves is subject is their distance from the Steam-ports into the Cylinder, and the large quantity of steam which occupies the space between the cut-off valve and the working cylinder of the Engine. To remedy these defects, and to apply a better system of expansion to the common Condensing Engines, the following apparatus and mode of working the valves was introduced.

In giving a description of this effective and simple apparatus, it is but fair to state that the first idea of this invention was suggested by Robert Brownhill, at first imperfectly constructed, but since greatly modified and perfected by the author of the present paper.

The annexed Drawings represent the cylinder and side pipes of a sixty horse-power Condensing Engine. Fig. 1 is a front view of the Steam Chests and Cylinder; Fig. 2 a side view; Fig. 3 is a section of the side pipes, Steam Chests, and Valves; and Fig. 4 an enlarged section of the Valves: the letters referring to the different parts are the same on all the figures. It will be observed that the Cylinder A, the Steam Chests C D, and the side pipes F G, are common to every Engine of this description; the internal construction of the Steam Chests, Valves, and the mode of working, are peculiar and constitute the chief merit of the invention.

In the construction of a Steam Engine, two important considerations present themselves, the attainment of a maximum of force, and the minimum in the consumption of fuel; to acquire the first it is requisite to form such an arrangement of the working parts, as to obtain the closest approximation to a perfect vacuum under and above the Piston, and the other is accomplished by having as small an expenditure of steam as possible. These desiderata are to a great degree attained by the principle upon which these Valves are constructed, and the way in which they are worked. Referring to Fig. 3 it will be seen that each of the Steam Chests C D contains two double beat Valves S T, also

the Shut-off Valve R and the Throttle Valve Q ; these valves constitute the whole of the openings by which the steam is admitted and returned from the Cylinder, the Valves S S next to the Steam Pipe E are the valves by which the steam is admitted to the Cylinder, and the Valves T T are the exhaust or the valves by which the steam escapes from the Cylinder to the Condenser. All the four valves are of the same area and dimensions, but the steam valves are not lifted up so high as the exhaust valves, for the reasons which are afterwards given. The direction of the arrows at C D, F G, &c., exhibit the passage of the steam in its ingress to the Cylinder, and its ultimate escape at H to the Condenser. The double beat Valves of this construction have certain proportionate areas, the upper portion being larger than the bottom, in the ratio of 1.158 to 1.000. The object of this enlargement of the upper part of the valve being to give a preponderance to the pressure of the steam on the top side, in order to overcome the pressure of the packing in the stuffing box which embraces the spindle, and to assist the gravitating force of the valve in its descent when liberate dfrom the Cams P P.

The mode of working the valves is by the Shafts and Wheels marked upon the Drawing I K L, they derive their motion from the Crank Shaft and revolve at the same speed ; the vertical Spindle I I, upon which the two Circular Discs P P are fixed, passes through the Steam Chests C D, and by its rotary motion the Cams which are fixed upon the Discs P P raise the valves as they pass under the Rollers N N, which are connected to the valve spindles by the cross heads M M, and by these means the valves are raised and retained open or shut for any definite period. The Rollers N N are steadied by the cross heads M M sliding upon the vertical guide rods O O at their outer ends, and sliding at their inner ends in vertical grooves in the centre boss U, which is supported by the guide arms O O.

To work this Engine economically much depends upon the pressure of the steam and the amount of expansion given to the valves ; the usual practice is to work with steam at 15 lbs. on the square inch and cut off at one half the stroke, and expand the other half ; but in other cases when the Engines and Boilers are calculated to bear a high pressure of steam, say from 30 to 40 lbs. on the inch, the cams are formed so as to cut off the steam at $\frac{1}{3}$ or $\frac{1}{4}$ of the stroke. As is shewn in the Drawing at P P, there are generally three and sometimes four Cams upon each of the Discs, so as to cut off the steam at one-half, one-third, or one-fourth, or at any other point corresponding with the force of the steam and the load respectively.

To obtain this range of expansion the Rollers N N which work the Steam Valves are moveable, by brass strips which slide in the grooves in the cross heads M M, so as to bring the Roller over any one of the Cams that may be required; and the fixed Pointers V V show by a graduated scale on each brass slide, the exact point of the Cylinder at which the steam is cut off, and by these means the extent of expansion is regulated and brought under the eye of the Engineer.

It has already been stated that the Steam Valves are not lifted so high as the Exhaust Valves, and the reason of this is, that as the exhaust valves are not variable in their action, and always require full openings into the Condenser, it is desirable to retain them open throughout the whole length of the stroke. This process is effected with a greater degree of certainty than by any other description of valve; the exhaust valves are raised suddenly by the short inclined planes of the cams, and having allowed time for the escape of the steam from the Cylinder through a wide passage into the Condenser, they suddenly fall by gravitation, and thus a more complete vacuum is formed under the piston than is probably attained by any other process.

The working of these valves is effected with a degree of certainty and simplicity which renders them very satisfactory both as regards their efficiency in conducing to the economy of steam, and the perfect ease with which they are worked.

The CHAIRMAN observed, that the principal part of the improvement described in the paper, appeared to consist in the arrangement for effecting the expansion action by cams revolving horizontally.

Mr. W. SMITH said, he had seen several engines working with this expansion gear, and could testify to the superiority of their action, the expansion gear was very simple and worked exceedingly well; he had taken indicator diagrams from the engines. He was not acquainted with any cases where this plan had been at work for a long time, and he had some doubts as to the lasting of the parts.

Mr. McCONNELL remarked, that was a matter on which they could scarcely express an opinion unless furnished with accurate data respecting the working. The Cornish engine reports were very complete as to the performance of the engines and the consumption of fuel; and if they had such information with reference to the working of the invention in question, it would be highly

important as regards the improvement of the engine and its economical results.

Mr. COWPER suggested the desirability of making a collection of indicator diagrams in the Institution, and expressed his willingness to co-operate with other members in supplying some.

Mr. W. SMITH said, it was his intention at an early meeting to lay before the Institution several hundred indicator diagrams which he had taken from engines in Staffordshire and the surrounding district.

Mr. McCONNELL observed, that the meetings of the Institution would afford parties connected with large manufacturing establishments an excellent opportunity for comparing the working results of engines in full action, not only in Staffordshire, but in Lancashire and other districts, and it was desirable that this class of information should be as perfect as possible.

Mr. SLATE thought the diagrams referred to would read an important lesson to the parties employing steam engines, and induce them to look after their own interests and not waste their power. He had seen a number of Mr. Smith's indicator diagrams, and the results of them would surprise many; most of them showed a very inferior action, and some showed only 5 lbs. per inch of vacuum with 13 lbs. per inch of steam, but there were a few good diagrams amongst them.

Mr. GIBBONS remarked, that one important thing they would have to attend to was the description of fuel used, which varied so greatly in Staffordshire as to render it a matter of great difficulty to collect accurate data.

Mr. W. SMITH thought it very desirable to know the description of fuel and the consumption, wherever it was practicable; but all that he proposed at present was to lay before the Institution diagrams exhibiting the economy of the engine, and not the consumption of fuel.

Mr. McCONNELL suggested that they should not confine themselves to the relative economy of the different constructions of engines, but they should also take into consideration the different constructions of boilers and the relative consumption of fuel for the power produced, as well as the kind of fuel employed. He saw no reason why the reports of engine performance should

be confined to Cornwall, for it would be highly important to have them for the various other districts, more especially Staffordshire, Lancashire, and Newcastle.

Mr. Gibbons remarked, that this would be extremely difficult to obtain in Staffordshire, because the quality of fuel varied to an extraordinary extent. In that district they had a considerable boiler surface, and in many cases used only coal-slack for fuel, which was good for nothing else; but in Cornwall the quality of fuel was tolerably uniform, and the best qualities of coals were used.

Mr. Slate proposed to omit the consideration of the consumption of fuel, as the fuel was not bought in the coal districts, but merely taken from the heap as required, and it would not be practicable in most cases to obtain any accurate return of the consumption.

Mr. W. Smith said, the question of fuel could not be included in the iron districts because it was customary in many cases to generate the steam by the waste heat of the puddling furnaces, and in consequence those cases would shew no consumption of fuel; but on the contrary, in other cases the consumption was greatly above the usual proportion, either from the inferior quality of fuel used, or from the engines being often worked much below their boiler power, and wasting from the boilers even more steam than was used.

The Chairman observed, that it took a great deal at first to induce the proprietor of a steam engine to look well after its working, but in Manchester considerable attention was now paid to the subject. There were many works where the consumption was as low as 4 lbs. per horse power per hour, but he should say that the average of Lancashire engines was twice that amount of consumption if not more.

Mr. McConnell thought that was a strong argument for taking up the question in the broad view; for without considering any particular district, it was very important for a manufacturer or other proprietor of a steam engine to know what his engine was doing as compared with the engines of other parties. Those engines in the same town or district could be fairly compared, and any particular causes for exception could be stated in the return.

Mr. Slate observed, that there were a few pumping engines in Staffordshire which were worked by contract, and their fuel was all measured, so that the consumption could be correctly ascertained; but those engines were an exception in the district.

The Secretary then read the following paper by Mr. David Burn, of Newcastle.

ON THE SYSTEM OF VENTILATION IN THE WALLSEND COLLIERY.

The Wallsend Colliery is situated about 3½ miles to the east of Newcastle-upon-Tyne. It is celebrated for having been the source of immense wealth to its late proprietors; and from the acknowledged superiority of the coal produced from this mine, arose the practice of appending the term "Wallsend" to such coals as were considered suitable for household purposes, indicating the class to which they belonged.

The seam of coal known by the name of the "Bensham Seam" is found in this Colliery, at the depth of 145 fathoms from the surface. Since the opening out of this seam twenty-nine years ago, there have been several explosions of Fire-damp, attended with a great loss of life, fully but unhappily entitling it to the appellation of a "fiery mine." In the course of working this seam, the following explosions and loss of life have occurred, from its opening to the present time.

In 1821	...	1 explosion	...	52	lives lost.
„ 1832	...	1 ditto	...	1	ditto
„ 1835	...	1 ditto	...	102	ditto
„ 1838	...	1 ditto	...	11	ditto
Total		4 explosions	...	166	lives lost.

The total thickness of the seam is 5 feet 8 inches, and it is divided by a band 8 inches thick, consisting of argillaceous shale and splint coal, the coal being 3 feet thick above this band and 2 feet thick below it; the roof consists of argillaceous shale. The quantity of coal raised annually from this seam is about 68,000 tons; but this quantity is considerably less than the powers and means of the Colliery are capable of producing, owing to the present depressed state of the coal trade. There are generally employed in the mine at one time about 210 men and boys, and 15 horses. Another seam of coal, the "High Main Seam,"

is situated 34½ fathoms above the "Bensham Seam;" this was first opened out in 1781, and it was abandoned in 1831; during that period five explosions occurred in working the seam, causing the loss of 26 lives.

There are five Shafts sunk to the Bensham Seam, as shewn on the accompanying Plans, Nos. 1 and 2, which are drawn to the scale of 2 chains per inch; No. 1 is a Plan of the Workings, and No. 2 a Plan of the Ventilation, shewing the several currents of air that are passed through the mine. The shaded portions of the workings shows where the coal is entirely removed. In the two Shafts C and D the air descends into the mine, and after circulating through the workings in the manner hereafter described, it ascends in the Shafts A, B, and F. A furnace is constantly burning at the bottom of each of these three ascending shafts, to produce the draft of air and keep up an uninterrupted ventilation; these furnaces are 8 feet wide and 6 feet long, and each of them consumes about 1½ tons of coals per day. The descending Shafts C and D vary from 7½ feet to 10 feet in diameter, and the ascending Shafts A, B, and F, from 5½ feet to 8 feet in diameter.

The Workings of this mine are divided into nine Districts, numbered from 1 to 9 on the Plan, which have in most cases distinct currents of air for their ventilation, and are in some degree unconnected with each other; a system which was carried out to a great extent in this Colliery by the late Mr. John Buddle. The five Districts, Nos. 1, 2, 3, 4, and 5, which are supplied with air from the Shaft C, are all coloured Red on the Plans; and the three Districts, Nos. 6, 7, and 8, supplied with air from the Shaft D, are coloured Blue. The general course of the air currents is shown in the Plan of the Ventilation, No. 2, by Red lines for the C shaft ventilation, and Blue lines for the D shaft ventilation; and the detailed course of the air through the workings is shewn by the arrows in the Plan of the Workings, No. 1.

The following are the particulars of the quantity of air that is circulated through each of the Districts. The currents were measured with Biram's Patent Anemometer; and on the day of measuring the quantity of air passing in each of these currents, the Barometer at the surface stood at 29.35 inches, and the Thermometer at 53 degrees; the wind South-East, morning dull with the appearance of rain.

In the following description the "Pillar Workings" are where the whole of the remaining part of the seam of coal is in course of being extracted. The "Air Crossings," where one current of air crosses another current, consist of a brick arch or a timber erection, by means of

which one current of air passes underneath and the other current above, without any communication between the two currents.

The Column of Air descending the C shaft consists of 75,960 cubic feet per minute, and is distributed in the following manner. At a short distance from the shaft, at the point marked K on the plans, the first division of this current takes place; 22,010 cubic feet of air per minute is carried into the "First District," which, after ventilating the passages on the west side and the workings at the northern extremity, is again divided at the point marked L; 10,400 cubic feet per minute passing to the A upcast shaft and over its furnace, and the remaining quantity of 11,610 cubic feet per minute passing into and circulating through the workings forming the "Second District." On leaving this district, and entering the "Third District," it is joined by another current, diverted from the main column of air at the point M, and consisting of 10,500 cubic feet per minute; this augmented current is then carried through the workings of the Third District, and thence over the furnace at the bottom of the F upcast shaft.

The remaining quantity of the principal column of air from the C shaft, now reduced to 43,450 cubic feet per minute, is again divided at the point N, where 15,750 cubic feet per minute passes into the "Fourth District," ventilating the Pillar-working P, and passing from thence into the F Shaft by an inclined drift, entering the shaft at the height of about 60 feet from the bottom, and consequently not passing over the burning furnace. The passing of this current of air into the shaft without its coming into contact with the furnace, is rendered necessary from its being on many occasions mixed with Fire-damp, or Carburretted-hydrogen to the exploding point, caused by the discharge of this gas from the falling of the roof, and eruptions from the thill or underclay of the coal seam.

Of the remaining column of air 7,500 cubic feet per minute is carried eastward and along the Pipe-drift or Gas-drift R, to the B upcast shaft, diluting in its passage the leakages of gas from the stoppings or walls sealing up the dormant or Pipe District, No. 9, and the discharge of Gas from the old workings S, near its southern exit to the shaft. And 20,200 cubic feet per minute is passed through the workings of the Fifth District, and thence to the F shaft; 7,200 cubic feet of which passes over the burning furnace, and the remaining 13,000 cubic feet per minute enters the bottom of the shaft without passing over the fire.

The following is a summary of the different divisional currents of air comprised in the aggregate column descending the C Shaft:—

	Cubic Feet per minute.
1st and 2nd Districts	22,010
3rd ditto	10,500
4th ditto	15,750
5th ditto	20,200
Pipe-drift to the B Shaft	7,500
	75,960

The quantity ascending the F Shaft being as follows :—	
1st, 2nd, and 3rd Districts	22,110
5th ditto	7,200
The quantity passing over the fire being	29,310
Add the quantity passing into the Shaft without going over the furnace :—	
4th District entering the Shaft by the inclined drift mentioned before	15,750
5th District entering at the bottom of the Shaft	13,000
Total quantity ascending the F Shaft	58,060

The column of air descending the D Shaft consists of 45,400 cubic feet per minute, and is diverted into the following Districts, ascending at the A and B upcast Shafts.

	Cubic Feet per minute.
The quantity of air passing into the 6th District, ventilating the workings on both sides, and carried to the B upcast Shaft	17,400
The quantity of air carried into the 7th District and Pillar-workings P, and passing by an inclined drift into the A upcast Shaft, evading the furnace	16,800
The quantity passing through the workings of the 8th District, and mixing with the various discharges of Gas from the old workings T T, in its course to the A Shaft; being also joined by the current from the 7th District before arriving there	11,200
Total quantity descending the D Shaft	45,400
Ditto descending the C Shaft	75,960
Making a total quantity of air descending into the Bensham Seam of	121,360

The area of the coal field which this system of Ventilation comprises is about	400 Acres
The area of the Workings of the 9th District, which are isolated and closed up to the Gas Pipe in the C Shaft as described afterwards, is about	50 Acres
Total area........	450 Acres

The total length of passages or Air-channels ventilated by the currents of air already enumerated, amount to about 24 miles in the C Pit Workings, and 7 miles in the D Pit Workings.

The total quantity of air circulating through the passages of this Mine amounts to 174,758,400 cubic feet per day; and the cost of working the furnaces, including their consumption of coals, amounts to 19*s.* 1*d.* per day, or £347 per annum.

The ordinary changes of the atmosphere, as indicated by the Barometer, have not the effect of charging any of the currents proceeding from the workings of the whole mine (or air passing over the furnaces), with fire-damp in an appreciable degree; but under like circumstances the currents from the Pillar-workings and the Pipe-drifts, are generally heavily charged with Carburretted-hydrogen, relieved by the change of atmospheric pressure from its vast magazines or gasometers formed by the total removal of the seam of coal.

In the same seam of coal, and situate to the east and south of the C Shaft, is the 9th District, coloured Green on the Plans, which is a district of workings lying dormant, being closed off from the ventilated part of the mine by a line of Stoppings or substantial brick walls. The only exit for the gas generated in this district is a pipe O carried up in the C shaft to the surface, where the gas burns with great brilliancy. When last measured, the quantity issuing from this pipe was found to be about 95 cubic feet per minute; an amount nearly equal to half the consumption of the town of Newcastle.

Some time ago the idea was entertained of lighting the town of Newcastle with the gas generated from this source; but on experimenting, it was found that its illuminating power was so exceedingly low, as to render it utterly useless as an economic light. However, since the present proprietors leased the Colliery, the attention of Dr. Richardson, the eminent chemist of Newcastle, has been called to the subject, the result of which was, that he suggested the use of a very simple and cheap ingredient containing a large quantity of carbon, by passing the gas through which, its illuminating power was raised to a point fully equal to the best coal-gas,—together with a large increase in volume. The

quantity of gas might be increased to a great extent by barring off and piping the gas from other parts of the mine; and the subject of beneficially employing the gas is at present under consideration.

The following is the analysis of the gas issuing from the gas-pipe in the C shaft, and the gas evolved from the Workings of the Bensham Seam; vide the Reports of Sir H. T. De la Beche and Dr. Playfair.

	Pipe.		Workings.
Carburretted-hydrogen	92 . 8	......	73 . 9
Nitrogen	6 . 9	......	24 . 9
Carbonic Acid	0 . 3	......	1 . 2
	100 . 0		100 . 0

Since the present proprietors commenced working this mine in 1847, they have instituted the general use of the Davy-lamp, to provide not only against the ordinary risks of the working of a "fiery mine," but also the risk from sudden eruptions or discharges of gas, now well known to have caused so many of the great explosions that have unhappily occurred in this Coal District.

Appended is a copy of the rules and regulations, which are strictly enforced, respecting the use of the safety-lamp, and the precautions to prevent the risk of explosion in the working of this Colliery.

Rules and Regulations to be observed by the Officers and Workmen of the Wallsend Colliery.

Any person observing any door standing open that ought to be shut, any stoppings injured, brattice knocked down or broken, or any other circumstance whereby the ventilation of the Mine may be deranged or obstructed, is immediately to inform the Overman or Deputy or other person then in charge of the Pit.

No Hewer to commence working in any place until it has first been examined by the Overman or Deputy or other authorized person.

No Workman to work in any place where he considers the timber, &c., insufficient to support the roof of the Mine, or any other cause that may render the place unsafe, until the Deputy or other person has made it secure.

The Overman, Deputies, or other Inspector appointed for that purpose, shall carefully examine and lock every Lamp previous to its being taken from the "Cabin" or "Station," and any person having an imperfect or broken Lamp is not to be allowed to pass to his employment until he shall have given a satisfactory reason for any such damage; but,

if caused by carelessness or neglect, he is not again to resume work until the case is laid before the Viewer.

Every person who has the use of a Lamp shall take home the gauze thereof, for the purpose of its being properly cleaned before it is again used.

No person, on any pretext, to leave the "Cabin" or "Station" until the Deputy or other Inspector has examined and found his Lamp to be perfect.

The Hewers to hang their Lamps at such a distance from where they are working, as to prevent the possibility of their being injured by splinters from the coal or other casualties.

No Putter, Pony Driver, or Helper-up, is, under any pretext whatever, to carry a Lamp during his work; a sufficient number will be placed in the Going Roads to afford light for the performance of the work.

Any person seeing another using his Lamp in an improper manner, is strictly enjoined to inform the Overman or other person in charge of the Pit.

All persons are hereby strictly prohibited from interfering in any way with their Lamps, further than the necessary trimming of the Wick with the Picker.

Any person losing his light is to send his Lamp out by the proper person appointed for that purpose, but not to be again used until it is examined.

Any Hewer or other Workman getting any Blower or sudden Discharge of Gas, or observing, by the usual indications, the presence of Fire Damp, is immediately to draw down the Wick of his Lamp, and, should the Fire-damp inside the Gauze continue to burn, to protect it from the current by his clothes or other means, to apprize the Men and Boys working near him, that their Lamps may be likewise extinguished, and to retire into the fresh air by the Intake Air-course, if possible, until the Overman or other person then in charge of the Pit is informed of it.

Any person acting contrary to these Regulations shall be immediately turned from his employment, fined, or prosecuted according to Law, at the option of the Owners or their Viewer, the safety of the lives of the Workmen depending upon the strict observance of these directions; and all parties are enjoined to aid in the detection of any such Offenders.

Mr. Clift observed, that he was aware such an application had been proposed of the waste gas from coal mines, but it was proved not to be of sufficient illuminating power for use in light-

ing a town. The plan suggested to obviate this defect was by charging it with coal-tar naptha, for the gas generated in the mine was the sub-carburretted hydrogen, and was deficient in the element of carbon; hence though it burnt very freely it yielded but little light. If however, it could be collected in sufficient quantity and with due regularity, it might easily be rendered available for street illumination by putting a small sponge-box on the burner, and by the gas passing through a sponge saturated with naptha it would acquire considerable brilliancy. There was at the present time a similar discharge of gas in the neighbourhood of West-Bromwich, but in that case also there was a deficiency of illuminating power.

Mr. GIBBONS expressed a doubt whether the plan of working the mine as detailed in the paper was not inferior in economy and efficiency to the mode adopted in Staffordshire; and he thought if the number of shafts were increased the facilities for ventilation would be much greater. He stated that his coal mine was ventilated easily by a stream of air along the face of the workings, with several outlets at the top for the gas to escape; a great portion of the gas was carried in a stream at the top without mixing with the air, on account of its lightness, and a much less quantity of air was required in proportion in consequence of the gas being so much less diluted with air. In that case, however, the seam of coal was very much thicker; the total thickness of the seam was 24 feet, and it was worked in two heights of 12 feet each.

Mr. SLATE remarked, that the collieries in the North were of much greater extent than those in Staffordshire, which were usually not more than about 20 acres in extent; the former were also generally of greater depth, and sinking the shafts was very expensive and difficult on account of the depth and the hardness of the strata.

Mr. CLIFT observed, that the excellent plan of ventilation which had lately been introduced, of using jets of high-pressure steam to propel the air through the workings, was found to be very successful. He had employed steam jets for the purpose of emptying gas-holders, and he was astonished at the short time in which the gas could be expelled from a large gas-holder by that means.

The CHAIRMAN then announced that the Ballot lists had been opened by the Committee appointed for the purpose, and that the following new Members were elected.

MEMBERS.

Mr. Benjamin Best, Dudley,
Mr. William Courtney, Dublin,
Mr. Jonathan Harlow, Birmingham,
Mr. Samuel McCormick, Dublin,
Mr. Walter McLellan, Glasgow,
Mr. James A. Shipton, Manchester.

The CHAIRMAN also announced that the meeting of the British Association for the Advancement of Science, would be held in Birmingham in September next.

A vote of thanks was passed to the Chairman, and the proceedings terminated.

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INSTITUTION

OF

MECHANICAL ENGINEERS.

REPORT OF THE

PROCEEDINGS

AT THE

GENERAL MEETING,

HELD IN BIRMINGHAM, ON 24TH OCTOBER, 1849.

ROBERT STEPHENSON, ESQ., PRESIDENT,

IN THE CHAIR.

BIRMINGHAM:
BENJAMIN HUNT AND SONS, 75, HIGH STREET.

1849.

PROCEEDINGS.

The usual General Meeting of the Members was held in the Theatre of the Philosophical Institution, Cannon Street, Birmingham, on Wednesday, the 24th October, 1849; Robert Stephenson, Esq., M.P., President of the Institution, in the Chair.

The minutes of the last General Meeting were read by the Secretary, and confirmed.

The Chairman announced that, according to the Rules of the Institution, the President, Vice-Presidents, and five of the Council would go out of office at the end of the present year, and that at the present meeting the Council and Officers for the succeeding year were to be put in nomination. He then read the following list of Members whom the Council proposed for nomination.

President.

Robert Stephenson, Esq., London.

Vice-Presidents.

Three of the number to be elected.

Charles Beyer, Esq., Manchester,
William Buckle, Esq., Birmingham,
J. E. McConnell, Esq., Wolverton,
John Penn, Esq., London,
Joseph Whitworth, Esq., Manchester.

Council.

Five of the number to be elected.

Charles Beyer, Esq., Manchester,
William Buckle, Esq., Birmingham,
Thomas Cabry, Esq., York,
J. E. Clift, Esq., Birmingham,
William Hartree, Esq., London,
P. R. Jackson, Esq., Manchester,

J. E. McConnell, Esq., Wolverton,
John Penn, Esq., London,
J. Scott Russell, Esq., London,
Archibald Sinclair, Esq., Glasgow,
William Weallens, Esq., Newcastle-on-Tyne,
Joseph Whitworth, Esq., Manchester.

TREASURER,

Charles Geach, Esq., Birmingham.

SECRETARY.

W. P. Marshall, Esq., Birmingham.

No other names having been added by the Meeting, the list was adopted.

The CHAIRMAN then called on Mr. Samuel of London, to read his paper,

ON THE ECONOMY OF RAILWAY TRANSIT.

The object of the present paper is to show that the Locomotives now in use on most of the railways have outgrown the wants of the Passenger Traffic, and that the weight on the driving wheels of these locomotives, amounting in some cases to 14 tons, is perfectly unnecessary for the number of passengers conveyed in 99 cases out of 100.

For the purpose of obtaining practical data upon this subject, the writer of the present paper procured a return of the number of Passengers conveyed on the Eastern Counties and Norfolk Railways, both Main Line and Branches, by each train during the week ending 7th May, 1849; this return showing the greatest number of passengers in each train at any one time.

It appears from this return that the greatest number of passengers in any Main line train at any one time was 231, and the least number 7; the greatest number in any of the Branch line trains being 82, and the least number 3.

And by another return from the books of the Company it appears that there were conveyed on the Eastern Counties Branch Lines during the year 1847, 42,644 tons of Passengers (calculating each passenger with his luggage at 168 lbs.), and that the weight of Engines and Carriages required to convey them was about 1,112,500 tons, being in the proportion of 26 to 1.

On examining the Coke Returns it also appears that the Main line engines consumed from 24½ to 40½ lbs. per mile, and the engines

for working the Branch line trains consumed from 16½ to 35½ lbs. per mile, varying of course with the size of the engine employed to do the work, the smallest engines invariably consuming the smallest quantity of fuel for the same work done. The average consumption of coke during the half year ending 4th July, 1849, was 31½ lbs. per mile for Passenger engines, and 47¾ lbs. per mile for Goods engines.

These returns refer to a stock of about 200 engines, and a length of line of about 310 miles.

Thus the writer came to the conclusion that it would be possible to construct a Carriage and Engine combined, of sufficient capacity for Branch Traffic, and by his advice the Directors of the Eastern Counties Railway gave orders to Mr. Adams to construct such a carriage, subject to the approval of Mr. Hunter, the Locomotive Superintendent.

The carriage was accordingly built, and called the "Enfield," from the Branch which she was intended to work.

The Diagram shows the "Enfield." The Engine has 8 inch cylinders and 12 inch stroke; Driving Wheels 5 feet diameter; distance between centres 20 feet; width of Framing 8 feet 6 inches. The Boiler is of the ordinary locomotive construction, 5 feet long by 2 feet 6 inches diameter. The Fire-box is 2 feet 10½ inches by 2 feet 6 inches.

There are 115 tubes of 1½ inch diameter and 5 feet 3 inches in length, giving a total of 230 feet heating surface in the tubes. The area of the Fire-box is 25 feet, giving a total heating surface of 255 feet.

The weight of this Steam Carriage is 15 tons 7 cwt. in working trim. The Engine and Carriage being combined, it is evident that the weight on the driving wheels is increased by the load carried, and that this weight increases in the same ratio as the load required to be taken.

The extreme distance between the centres of the leading and trailing wheels being 20 feet, accounts for the steadiness of this machine; there is indeed no perceptible oscillation when travelling at the highest speed, and this verifies the observation "that the steadiness of an Engine depends not on the position of the Driving Wheel, but upon the length of the Rectangle covered by the wheels." This Engine at the same time daily traverses curves of 5 or 6 chains radius.

The "Enfield" Steam Carriage was originally intended to convey 84 passengers, but as it was found that when she was put on as an Express Train the passengers increased in number, a "North Woolwich" Carriage was attached capable of conveying 116 passengers, and also a Guard's Break Van, making provision altogether for 150 passengers, which is now her regular train taken at a speed of 37 miles per hour.

This Engine commenced her regular work about eight months

since, and the following return shows the miles run and coke consumed by this Engine during the 7¼ months regular working from January 29th to September 9th, 1849.

14,021	total miles run.
705	hours, running time.
1,457	ditto, standing time.
2,162	total hours, in steam.
743	cwt. coke consumed in running.
408	cwt. ditto standing.
286	cwt. ditto getting up steam.
1,437	cwt. total coke consumed.
11·48	lbs. per mile average consumption of coke.

The "Enfield" is in steam 15 hours per day, the fire being lighted about six in the morning and drawn at ten o'clock at night. But of these 15 hours it appears by the return that she is engaged running only 5 hours, the remaining 10 being employed standing in the siding. It was found by experiment that the quantity of coke consumed standing was 32 lbs. per hour, and after deducting this and the quantity consumed getting up steam, it will appear that the actual consumption of coke running is under 6 lbs. per mile.

It must also be particularly borne in mind that this consumption of coke includes the total Goods and Coal Traffic on the Branch, amounting to 1410 tons; viz., 169 tons of goods and 1241 tons of coal.

The "Enfield" Steam Carriage worked the 10 a.m. Passenger train from London to Ely on 14th June, a distance of 72 miles, taking behind her three of the ordinary carriages and two horse-boxes; she arrived at Ely 8 minutes before time, and the total consumption of fuel, including the getting up steam, was found to be 8¾ lbs. per mile. The tubes of the boiler are only 5 feet 3 inches in length, and the economy of fuel is consequently scarcely at the maximum.

Another Engine on a similar plan to couple with a 40 feet carriage is now nearly ready, the tubes being 6 feet 6 inches long, from which is expected even more economical results.

The result of the writer's experience is the conviction, that for Express purposes, and for the larger portion of the Branch Traffic on railways, the light Steam Carriage is the best adapted and most economical machine, both as to first cost compared to the work done, and in working expenses.

The repairs of the Permanent Way are also very much reduced, as may be easily imagined.

The philosophical analysis of the question appears to be as follows: Railways are constructed for the transit of passengers and goods; for the latter, which are capable of division into small parcels, some latitude of form and structure may be allowed; for the former, the stature and properties of man give a fixed standard. The carriage in which men are borne should be lofty enough to permit of standing upright when desired, for comfort to the rich and economy to the poor, as a larger number may be conveyed standing than sitting in a given space. The height being settled, the *width* must be so proportioned as to exceed the height by nearly one-third in order to induce steadiness, bearing in mind that in a Railway Carriage there are two bases, the "Spring Base" of the Frame on the Axles, and the "Wheel Base" of the Wheels on the Rails. To secure a sufficiently wide "Spring Base" the Axles should be projected beyond the wheels, and in practice a body 9 feet wide may be obtained, where the width of the railway in centre and side spaces will permit. But this width being obtained, it becomes essential to get a proportionate length to insure steadiness. Practice has verified this on the Eastern Counties Railway, where for two years past carriages 40 feet long and 9 feet wide, on 8 wheels (30 feet from centre to centre), have been traversing the most difficult curve and gradient in England, the radius at one part being 189 feet.

The largest floor area per wheel—the minimum of dead weight compared with the load and the carriage, with least resistance to traction is thus attained. The result of this is, that the minimum of steam power is required to draw it.

No truth is more certain than that the number of travellers by railway is increased by the facilities given for travelling. If a large Engine and Train costs a given sum, and the departures are every two hours, supposing that Engine and Train could be divided into four, and a departure take place every half hour at no increase of expense, it might be assumed that the passengers would double their numbers; but it may easily be demonstrated that the expense would be lessened, because by improved arrangement the total dead weight is much reduced.

On the Eastern Counties Railway an Engine and Tender of say 30 tons, a Break Van, a First Class Carriage, and three Third Class Carriages, conveying say 120 passengers, make a total weight of 59 tons, and the consumption of coke, as has already been shown, is on the average 34 lbs. per mile. A Steam Carriage weighing only 17 tons will transport the same number of passengers at from 7 to 8 lbs. of coke per mile when the best proportions are attained.

The first cost of a large Engine, Tender, and four Carriages has been £4000. The Steam Carriage for the same number can be made for something less than one-half the cost.

The value of the Railroad in lessening draught consists in its perfect horizontal level, and not merely its general level, but its close approximation to the character of a lathe-bed—a hard, inflexible, smooth, true, and equable surface.

With heavy Engines having 5 tons weight or more on each driving wheel, it is impracticable to maintain any road that it is possible to construct in this condition; for supposing the timbering to be of sufficient surface, and the rails to be perfectly inflexible girders with their joints unyielding, the very iron itself will abrade beneath the tread of so heavily loaded a driving wheel, which whether of 8 feet or of 30 feet diameter, can only rest upon a mere point.

It is a matter of doubt whether more than 3 tons can be placed on a wheel at great speeds without destroying the metal.

But there is yet another question to consider. In order to start a train into motion a great amount of power is necessary, many times greater than that which is requisite to keep up motion.

This surplus power remains in the train under the name of momentum; and it must be obvious that the greater the total weight of the train the greater must be the momentum. If the road be in bad condition with loose joints, the momentum essential to the maintaining of motion is consequently absorbed by these concussions. In short, the joints are a series of holes, and many of our railways, relatively to the heavy engines traversing them, are practically worse roads than a well-made macadamised road is to a stage coach.

If thus the weights be reduced below the point which causes destruction, it is probable that the heavy item called "Maintenance of Way," and the still heavier item of replacement of rails, chairs, and sleepers will nearly disappear.

Mr. Samuel further explained the diagrams illustrating his paper, and remarked that the Fairfield Steam-carriage on the Bristol and Exeter Railway, had hitherto been worked with an upright tubular boiler, which had not proved satisfactory, and the regular working of the engine had been prevented by the difficulty in keeping the tubes tight; but a horizontal boiler had been substituted, and the engine was just starting to work with it.

The Chairman remarked, that the subject was one of great importance, and he hoped it would give rise to an interesting dis-

cussion, not leading into any unfriendly difference of opinion, but an exposition of a friendly difference.

Mr. McConnell said, the results given by Mr. Samuel in his paper afforded proof of great economy; but how far this description of miniature engine might be brought into use on railways in general, must be determined by actual experience to a greater extent than was yet afforded. He believed that the branch on which the Enfield engine had been running was as favourable for the trial of the engine as any that could be selected. He had himself had an opportunity of travelling on the engine from London to Enfield, when the performance was very satisfactory for the load conveyed; but any increase of load or additional amount of traffic would materially affect the performance of the engine, because with a just appreciation of economy it had been balanced as nearly as possible to the load expected.

If they could in the general management of railways ascertain the exact number of carriages required for the accommodation of the traffic, a great economy of locomotive power might be effected; but unfortunately, in practice, they were often required to provide something like a maximum of power for a minimum of traffic. He had no doubt that the circumstances of many railways, particularly in those districts where the traffic was nearly uniform, would oblige them to adopt a power more nearly corresponding to their wants and to the loads they had to take; for undoubtedly the power of many engines at present at work very far exceeded their real requirements. He agreed with Mr. Samuel that this extra weight on the rails must materially affect the question of maintaining the permanent way; and as the quantity of coke consumed while standing and getting up the steam are expenses constantly attending all engines, he thought Mr. Samuel was quite justified in taking credit for economy. He was not, however, prepared to say how far this description of engine might be made applicable; but should be very glad to see any effectual step towards economy in the expenditure of railways, and he thought Mr. Samuel deserved great credit for having made such an effort.

As applicable to the subject, he recollected that on the Birmingham and Gloucester Railway it was found desirable to employ an economical power for the purposes of traffic on the small

branch line from the main line to Tewkesbury, and for this purpose he adapted one of the small American engines by combining the engine and tender on one frame, and by putting a tank on the top of the boiler. But the gradients were very abrupt coming out from Tewkesbury, and when they worked the goods and passenger traffic together they were frequently obliged to increase the number of carriages, and in some cases the power was insufficient. The engine had 10½ inch cylinders, with 4 feet driving wheels, and 20 inch stoke; the consumption of coke was from 15 to 17 lbs. per mile; and the gradients varied from 1 in 300 to 1 in 80. The pressure, however, on the American engines was very fallacious, for the spring balance only indicated about one-third of the actual pressure on the boiler, which was really about 100 lbs. per inch.

Mr. ADAMS of Birmingham remarked, that the Enfield engine was all on one frame with the carriage; but a different arrangement was adopted in the Cork and Bandon engine, in which the engine and carriage were on separate frames; and he enquired the reason for adopting the former plan in the Enfield.

Mr. SAMUEL explained, that as the length of coupling of the engine wheels in the Enfield was only 5 feet 4 inches, with an 8 inch cylinder, it was necessary to attach the carriage and engine on one frame, otherwise it would be too short to run steadily; the effect produced by the carriage was like the stick of a rocket in steadying the motion. But in the Cork and Bandon engine with a 9 inch cylinder, the length of coupling of the wheels was 10 feet, and no carriage was required to produce steadiness, as the rectangle on the rails was so much longer. In the case of large engines, where the distance between the axles had been increased to 16 feet, a greater steadiness was observable.

There was accommodation in the carriage for 15 first class and 116 other passengers, giving a total accommodation for 131 passengers; and this he considered the most serviceable for working the express traffic. One of these Steam-carriages was being prepared for working on a railway in Scotland, at a contemplated speed of 40 miles an hour. At the present time it was impossible to keep the road in good repair, especially on the old lines, in consequence of the enormous weight of the engines.

Mr. SLATE asked whether it was anticipated that these small engines would prove as durable, and have as long a life-time as the present large locomotives.

Mr. SAMUEL replied, that he expected the small engine would be as durable for locomotive purposes, and even more so than an engine of larger dimensions; the bearings could be made larger in proportion to the strain, and the boiler being smaller in diameter the steam could be compressed with greater safety. The Enfield engine was worked at 120 lbs. pressure, while in ordinary engines it did not exceed 80, and hence an advantage of 40 lbs. was obtained. The heating surface of the fire-box was 25 feet.

Mr. McCONNELL said, they had a great number of small engines originally on the line, but they were not able to take the traffic. His experience was that in a long run the small engines exhausted themselves, and were not able to keep up their steam if they had anything like a load.

Mr. SAMUEL said he had, with the Enfield engine, made the quickest journey that had ever been performed between Norwich and London. With a train capable of containing 84 passengers they performed the distance of 126 miles in 3 hours 35 minutes, including stoppages. Another advantage in a large carriage of this description resulted from making use of the side space, for there were only 8 wheels to do the work of 24, and at the same time they had no greater amount of weight on each wheel than under the ordinary arrangement. The whole weight was 9 tons without passengers, and 84 passengers might be taken at an average as weighing 6 tons.

Mr. McCONNELL said, that undoubtedly with the present carriages the proportion of the tare to the passengers carried was very great; and although a case which rarely happened, instances had occurred where the tare was 50 tons to 3 tons of passengers. But even taking the weight of passengers at 10 tons, 50 tons of carriages was unquestionably a large proportion of dead weight to carry; and he considered that the long carriage, if always likely to be well employed, would be an advantageous mode of saving the dead weight, more especially on branch lines, and at the junctions where such branches came in.

The CHAIRMAN said, they were much indebted to Mr. Samuel

for bringing the subject before them; and he only wished that more of their railway friends had attended the meeting, for it was a paper which well merited their deep consideration in the present depressed state of railway interests. The question of economy in the heavy current expenses of railways had for some time occupied his attention; and although he did not go to the full extent with the proposer of this new system, he nevertheless went to a considerable extent with him, and admitted that there were cases of passenger traffic, and branch traffic, and sometimes even short local lines, such as that from London to Greenwich, London to Blackwall, or London to Broxbourne, where the number of short passengers was great, and the number left in long trains was very small, thus causing the train after a certain portion of the journey to work very disadvantageously. He had no doubt that companies would have to classify these trains to a much greater extent than had hitherto been done, and in that case the present plan might be tried with advantage; but he could not go with Mr. Samuel in saying that an engine so light as he had described was applicable to express travelling.

Even the principle of attaching a carriage to the engine for the purpose of giving adhesion, appeared to him a very doubtful expedient, because small engines were much heavier in proportion to their power than large ones. He considered that Mr. Samuel's arrangement in the case of the Cork and Bandon engine was a good one, but attaching a carriage to an engine was very objectionable; it was like riveting harness to a horse, and could not be desirable under any circumstances whatever. Mr. Samuel did so to increase the weight on his driving wheels, and consequently obtain more adhesion; but he forgot that he had already more weight on the driving wheels than was adequate to drag the carriage along. This was adding more than enough, because an engine that weighs only 5 tons is not so capable of slipping upon the rail as an engine that weighs 30 tons, and therefore attaching a carriage upon the frame of a small engine was superfluous, and the inconvenience arising from having them riveted together would in some cases be exceedingly great, more especially in working a station.

Cases however might presently arise which would be favour-

able to the development of the proposed system; for instance, railways had been laid down where hardly any justification existed for their construction; these must be worked at the least possible cost, and Mr. Samuel's plan might be adopted advantageously; but let not his very useful system be overstrained, because there was no great branch line, express or otherwise, to which it could by possibility be applicable. It would be largely applicable to minor branch lines, but he (the chairman) felt that if he were to allow this paper to be read without saying anything, considering the position which he occupied in the railway world, it would be taken as a tacit acquiescence on his part in the broad principle of applying small engines where in fact for a period of nearly 20 years (ever since 1831) they had been doing everything in an opposite direction to that which Mr. Samuel was now pursuing. Hitherto they had been contriving engines to develope railway traffic on the main trunk lines, where not only great dispatch, but great comfort, is exacted; and he would ask whether the public would be satisfied to be packed up like fish, ninety in a carriage. That they would not be content with inferior accommodation was sufficiently evident from the eagerness with which on the arrival at a station persons made their way to the four inside carriages, which he thought were much more conducive to comfort than the broad guage carriages with eight inside.

Mr. Samuel remarked, that in his carriages he thought there would be more and better accommodation than afforded by the present system, as not only were they 9 feet wide, but high enough for the tallest passengers to stand upright if they felt disposed.

The Chairman did not think that the loftiness of the carriage removed the objection, because it was quite possible for a crowd to be very closely packed.

Mr. Samuel replied, that he allowed the same floor area for each passenger as in the present system.

A vote of thanks was passed to Mr. Samuel for his paper.

The following paper, by Mr. McConnell of Wolverton, was then read.

ON RAILWAY AXLES.

When the railway system was first introduced into this country, the question of the strength of the materials for constructing the new stock

was (it is to be presumed) materially influenced, by the amount of experience derived from the vehicles which had previously been in use for the conveyance of traffic.

As the new system became extended and improved in all its arrangements, and the facilities which it possessed for conveying greater loads at higher speeds were gradually developed, the working stock was necessarily changed from time to time in conformity with the greater demands for convenience and stability. Improvements in almost every point have been carried out until we have now in operation the railway stock, generally speaking, in an excellent condition for the purpose to which it is applied.

It is remarkable that, notwithstanding the importance of proportion and quality as first elements in considering the strength of the materials of which railway moving stock is composed, no rule, generally applicable for even the main features of this great system of machinery, has been established.

Without attempting to embrace the whole subject, although one of great importance to proprietors of railways and the public generally, I conceive it is proper in this place to express my strong conviction that the general question of the strength and quality of those materials justly proportioned to the strains to which they are subject, and bearing reference to accidents from collision, faults of road, deterioration from a variety of causes, &c., must eventually be treated with great attention and consideration; and in order to insure safety to life and property for all who use railways, as well as the greatest possible economy for the profit of those who have embarked their capital in their construction, I believe it will be found essential to have some regulations founded upon the joint experience of those parties who have been practically engaged in managing and working the different departments of railways.

It is well known that short-sighted economy has been practised in many instances in giving directions for the purchase and repair of railway stock, and it is only dear-bought experience which can effectually convince those parties who, to make a little saving by purchasing a cheap ill-constructed machine, gain a great and constant loss whilst it is in use.

The advantages of a general and constant interchange of opinion among those parties to whose judgment and management the working expenses of the different railways are entrusted is most important; and if such varied experience could be collected regularly and systematically into one focus, where it might be digested and prepared for practical use, the effect for good to the general system of railways would be very great,

and, in a scientific point of view, the results recorded would prove highly interesting.

Having thus briefly stated a portion of my views as bearing upon the introduction of the best means of producing uniformity in the working stock of railways, I will now proceed to consider " Railway Axles," which, as an important part of the great machinery, are deserving of marked attention.

I have endeavoured to ascertain whether any data were available which might assist me in forming a groundwork of the results of combined experience on this subject; but I regret to say that, although my inquiries have been in all cases promptly and carefully attended to, yet the object which I had in view has not been attained.

As an example of the diversity of opinion, or rather perhaps the want of some certain rule to guide engineers in proportioning the strength of axles to their weights and strains, I would refer to the different forms of axles now in use on one portion of one railway, and in doing so would remark, that a clearer proof could not be afforded of the desirableness of some defined principle to guide us in deciding on the strength for railway axles.

For obvious reasons I wish particularly to guard against expressing, directly or by inference, any opinion on any description of manufacture of axle, or even quality of iron of which axles are composed. I would wish to limit the scope of the present paper simply to the question of the form and dimensions of axles, with the changes and deterioration to which they are subject in process of working, assuming in all cases the material of which the axles are made, and the mode of manufacture, to be of the most approved description.

In order to arrive at a knowledge of the best form and dimensions of axles, we have first to ascertain the load and friction to which they are to be exposed; and, secondly, to estimate as nearly as possible the strains to which they will be subject whilst in motion.

Supposing a waggon or carriage to be constantly in a state of rest, it would of course then only be necessary to consider the axle as a beam or girder, sustaining a load of 5 tons upon the two journals, the points of support being the wheels resting upon the rails; the middle portion of the axle being of sufficient strength to sustain the wheel or prop in its perpendicular position. We then require to find out the proportionate strength, so that each section of this beam or girder shall only be sufficiently strong to resist the strain or load to which it is then subject.

It is ascertained, by an approximate calculation, that a journal

1.198 inch diameter, is not capable of sustaining a heavier load when in a state of rest than 2½ tons, or 5600 lbs.; and allowing in practice that the waggon or carriage axle is made ten times the breaking strength, the diameter of the journal would be, adopting the same calculation, 2.43 inches. In these calculations the strength alone is considered, but we have also to take into account the question of friction and likewise the tendency to abrasion.

With our present means of information no accurate data are available for determining the best proportion of journal or bearing according to the weight it has to bear, or the velocity at which it is required to move. A great variety of proportion is in use, but it is fair to note that in engine-axles particularly, the length of bearings depends to a certain extent upon the construction and arrangement of the engine; as a general rule the length of the bearing is not in due proportion, according to our general experience, to the diameter.

It has always been considered that having first ascertained, from example and experience, the strength of sectional area necessary under under every circumstance to sustain the load which the journal has to carry, the length of it was determined by the velocity or amount of friction to which it is liable. Judging from axles at present in use in carriages and waggons, the length of bearing is twice the diameter of the journal; but on this, as well as other points on strength of material, there exists a great variety of opinion. Even the forms of journals are found to differ very much. Without attempting to decide on the merits of any of them, I shall in the present instance content myself with stating, that all my experience has proved the desirableness of maintaining the rubbing or wearing surfaces of bearings as free as possible from sharp abrupt corners, and sudden alterations in diameter or sectional strength.

Having thus treated the journals as regards the load and the friction upon them, I now proceed to estimate the various strains to which the axle is exposed whilst in motion.

The first strain to which the axle is subject is that arising from the weight of the waggon and load, which being received or resting on the journal produces the greatest effect upon the axle at the outer face of the wheel-boss, and to which is to be added the momentum of the load in falling through the spaces caused by inequalities in the joints of the rails.

The injurious consequences upon the axle of inequalities of the road surface, and flat places on the surface of the wheel-tyre, by the jolting or perpendicular motion which they produce, cannot be accurately

estimated, and these are very much increased when the bearing springs of the waggon or carriage are not sufficiently elastic, and do not yield to the shock or blow downwards, so as (to use the expression) to cushion its effect. As an instance of the imperfect action of the springs, I would allude to those in use on many waggons, in which the form and construction cause them to be so rigid that the downward blow is more like a hammer upon an anvil. To obviate this strain as much as possible, it is necessary to proportion the spring so as to sustain the load properly, and yet to be of sufficient elasticity to absorb the effect of the load oscillation.

The strain arising from the oscillation of the waggon on curves from imperfect coupling, and increased by the lateral freedom or space on the bearings or play between the rails and flanges of the wheels; which when an irregularity occurs on the side of the rail, or any sudden cause disturbs the direct motion of the waggon onwards, is in effect the same as a blow upon the flange of the wheel, the radius of the wheel tending to act as a lever to break the axle at the inner face of the boss of the wheel.

This strain is in the compound ratio of the momentum of the load, the angle at which the wheel strikes the rail, and the distance from the centre of the axle to the point of impact, producing an effective strain upon the axle at the inner face of the wheel-boss, which extends proportionately over the whole axle between the wheels. To lessen in practice as much as possible the deteriorating effect of these descriptions of strains upon the axle, the following conditions are important:—

That the bearings or journals of the axles fit as closely to the brasses as is consistent with freedom, the allowance of flange-guage of wheel being quite sufficient for the carriage to move freely round curves and and meet any irregularity in the guage of the rails.

That the waggons or carriages be as equally loaded as possible, and the draw chains be exactly in the centre; and as side chains are dangerous they should be completely removed, provision being made for a duplicate centre draw-chain should a failure take place. As the damage to the loading of waggons is in proportion to the oscillation, they should all be screwed together by means of screw-couplings, having spring-buffers upon both ends of every waggon.

It is well known that the injury to the waggon, to the load which it conveys, to the axle which carries it, and to the road over which it runs, is very much aggravated if the waggons are allowed to oscillate from side to side, and become like so many battering rams, injuring themselves and all substances in contact with them. A train of waggons

or carriages should be jointed together similar to the vertebræ of an animal, by which means any sudden lateral action would be neutralised by the support derived from the neighbouring vehicles.

The road to be kept as accurate as possible to guage and line.

The third class of strains to which axles are liable are the shocks produced by starting and stopping a train, and which are in proportion to the momentum of the wheel and axle at the time of collision when stopping, and to the velocity of the impelling force and the inertia of the wheel and axle when starting; these strains are felt principally on the neck of the journal.

Fourth strain—the torsion or twisting caused by the wheels travelling over curves of the line; the difference in length of surface of the inner and outer rail compels one wheel to grind or slide upon the rail, while the other is free to roll. This strain is proportionate to the load on the wheel, determining the amount of friction upon the rails and the length of axle between the wheels; a slight amount of torsion is also caused by any variation in the diameter of the wheels on the same axle, by any inequality upon each journal, the quality of the brasses, or the amount of lubrication proportionately, and the strain of the break block on one side, because when any of these occur separately or jointly, one-half of the extra strain on one journal is transmitted through the axle to the other, and twisting or weakening the axle is necessarily produced. To lessen the amount of the above strain, it is obvious that the wheels should be kept in the best possible state of repair so far as equal diameters and true circular surfaces are concerned, the waggons or carriages should be loaded equally on each side, the journals carefully lubricated, and all break blocks adjusted to bear the same pressure on both wheels of the same axle.

Fifth strain—the constant vibration of the whole axle. This is more particularly the case and is accelerated when the axle is fixed in a rigid, unyielding wheel. My experience has proved that the axles fixed in cast-iron wheels are very much more liable to deterioration than those in wrought-iron wheels, and the jar or vibration tending to deteriorate the quality of the iron, by altering its texture from fibrous to crystalline, is clearly visible in its effects in several fractures which I have seen. It would appear that the cast-iron wheel acted more like a hammer on the axle, and as in the cold-swaging process, a gradual breaking up of the fibre at the back of the wheel goes on, which is shown by an annular space, varying from $\frac{3}{8}$ inch to $\frac{3}{4}$ inch in breadth; the strength is completely destroyed of this outer portion, and a sudden shock of the wheel upon some point of the road completes the fracture of the axle.

Among other causes which contribute to the deterioration of axles may be mentioned the practice of throwing cold water on the axle to cool it, when it has become nearly red hot from the want of proper lubrication of the journal.

With regard to the strain to which the portion of the axle between the wheels is subject, there can be no doubt if the form of the axle is so proportioned, that any blow transmitted through the wheel is received equally along the whole body of the axle, and the sectional strength at each point is fairly balanced to resist the effect of the blow, the axle will then be best suited to prevent deterioration at any particular place.

With the view of determining the weakest point of a common waggon axle under different circumstances, I made a few experiments, as follows:—

In the first experiment the power was applied to the flange of the wheel, and the resistance (as in the case of a railway axle when running) at the centre of the opposite wheel; the result was that the axle began to bend from a straight line at $12\frac{1}{4}$ inches distance from the boss of that wheel to which the power was applied, and there is no doubt that if the power had been continued the fracture would have taken place within the $12\frac{1}{4}$ inches.

As a proof of this, in the second experiment, an axle of precisely the same dimensions and form, on being bent alternately backwards and forwards (the power being always applied on the same wheel at opposite points) was broken at the twelfth time of bending, within 6 inches of the back of the wheel.

In the third experiment the power and resistance were exactly in a parallel line to the centre of the axle, and the result, as might be expected, was a curve of a nearly uniform radius, proving that although the form of this axle was adapted to receive the blows of both wheels at precisely the same instant, and to the same extent (an impossible circumstance in practice), it was not suited to receive alternate strains or shocks, to which all axles are subject in ordinary use.

The sizes of the axles in the above three experiments were precisely alike.

In the fourth experiment another axle of the same dimensions was taken, and reduced at the centre in a lathe to the following dimensions: —The axle was divided into eight equal spaces from the back of the wheel to the centre of the axle. Immediately at the back of the wheel the axle was 4 inches diameter, and the deflection was $9\frac{1}{4}$ inches; at the first space the diameter was $3\frac{3}{4}$ inches, and the deflection was $8\frac{3}{8}$ inches; at the second space the diameter $3\frac{3}{16}$ inches, and

deflection 7 inches; at the third space the diameter $3\frac{1}{16}$ inches, and deflection $5\frac{5}{8}$ inches; at the fourth space the diameter $2\frac{15}{16}$ inches, and deflection $4\frac{1}{4}$ inches. Up to this point the axle maintained a straight form from the back of the wheel, and from this point to the centre of the axle, as shown by the deflections, it assumed a fair curve, proving that the axle was weaker towards the centre than it ought to have been, and that the first 12 or 14 inches from the wheel, having maintained the straight form, was stronger in proportion.

In the fifth experiment the axle was reduced to two inches and a half in the centre, and, with the power applied as in the last case, the weakness at the centre was more perceptible.

In the sixth experiment the axle was made of another form, weaker immediately at the back of the wheel and at the centre. We had here two bends or curves, with a straight portion between them.

In the seventh, there was an improvement upon the sixth, but it did not realise a perfect balance of strength at the different points.

In the eighth experiment this was fairly accomplished, the proportion being as follows:—From the back of the wheel to the centre of the axle the sizes were $4\frac{1}{16}$ diameter, $3\frac{1}{4}$ diameter, 3 inches diameter, $2\frac{7}{8}$ diameter, $2\frac{13}{16}$ diameter, $2\frac{3}{4}$ diameter, $2\frac{11}{16}$ diameter, $2\frac{11}{16}$ diameter, $2\frac{5}{8}$ diameter; the half-length of the axle being divided as before into eight equal spaces.

It must be evident that this can only be an approximate result, but we found that these proportions enabled us to attain the nearest approach to a regular curve in bending the axle; and it is worthy of notice that when the dimensions of the axle at the journal and in the boss of the wheel are determined, a calculation to ascertain the exact proportion between the wheels seems to confirm the above statement of dimensions in the eighth experiment.

The greatest strain to which this portion of the axle is subject, being received at the bottom flange of the wheel, and transmitted through its radius, the amount of strain which any portion of the axle has to resist is inversely as its angular distance from the point of impact is to the radius of the wheel.

Assuming the blow on the flange of the wheel to exert a breaking force equal to 102,229 lbs., and the diameter of the axle to be 4.71 inches to resist this blow, then, dividing the axle into four equal spaces to the centre, the proportionate breaking force at each point would be as follows:—At the first, 94,381 lbs., relative diameter, 4.59 inches; at the second, 80,697 lbs., relative diameter, 4.35 inches; at the third, 67,798 lbs., relative diameter, 4.11 inches; at the fourth, 58,899 lbs. relative diameter, 3.92 inches.

With regard to engine axles these proportions will apply where no circumstances exist of employing the centre of the axle for transmission of power. The crank axles of locomotive engines cannot be treated by any of the rules applicable to straight axles; and our experience would seem to prove that, even with the greatest care in manufacturing, these axles are subject to a rapid deterioration, owing to the vibration and jar which operates with increased severity, on account of their peculiar form. So certain and regular is the fracture at the corner of the crank from this cause, that we can almost predict in some classes of engines the number of miles that can be run before signs of fracture are visible; a certain amount of injury can be prevented by putting counter-balance weights opposite to each crank, which lessens the vibration very considerably.

It is right to observe in this place, that to some extent the injury to all axles may be increased, if the wheels in which they are fixed are not properly balanced, and I have no doubt that a great portion of the constant vibration to which they are subject may be traced to the knocking action of the wheel upon the rail, owing to a want of balance.

The question of deterioration of axles arising from the various causes, which I have enumerated, is a very important one to all railway companies; that some change in the nature of the iron does take place is a well-established fact, and the investigation of this is most deserving of careful attention.

I believe it will be found that the change from the fibrous to the crystalline character is dependent upon a variety of circumstances. I have collected a few specimens of fractured axles from different points, which clearly establish the view I have stated. It is impossible to embrace in the present paper an exposition of all the facts on this branch of the subject; but so valuable is the clear understanding of the nature of the deterioration of axles, that I am now registering each axle as it goes from the workshops, and will endeavour to have such returns of their performances and appearances at different periods as will enable me to judge respecting their treatment. When it is considered that on the railways of Great Britain there are about 200,000 axles employed, the advantage of having the best proportions, the best qualities, and the best treatment for such an important and vital element of the rolling stock must be universally acknowledged.

The CHAIRMAN observed, that as there were many members present well versed in the qualities of iron, he hoped they should have some observations from them tending to confirm or to call in question the positions taken by Mr. McConnell in his paper.

Mr. HENDERSON thought the subject was a very important one, and had been well treated in Mr. McConnell's paper; and he hoped the investigation would be carried out by further experiments.

The CHAIRMAN said, that Mr. McConnell had expressed a strong opinion, that a change took place from a fibrous structure in iron to a crystalline one during the time of its being in use; and it would be satisfactory if an instance could be pointed out where this change had occurred, owing to vibration or any other treatment, for he had not been able to satisfy himself from many experiments that any such molecular change took place. Hammering a piece of hot iron till it is cold produced a hardness called crystalline; but the question for consideration was, supposing an iron axle were annealed by heating to a dull red heat and being allowed to cool slowly, would the "texture" of that iron undergo any alteration afterwards from the vibration of the railway or any piece of machinery they were in the habit of employing. He had not been able to detect an instance of the kind; and in giving evidence before the Iron Girder Bridge Commission, he mentioned cases of vibration going on from year to year without any sensible change occurring in wrought or cast-iron. For instance, they had the Cornish engine beam with a strain of 50 lbs. per inch, working 8 or 10 strokes per minute for more than 20 years; and certainly if a molecular change was introduced by vibration, it ought to be by that continual concussion and vibration, but none was perceived. Again, the connecting rod of a locomotive was a piece of iron in a most perplexing situation, for one having more to do and having the strain changed more frequently it was difficult to conceive; and yet he had known the connecting rod of a locomotive engine to vibrate 8 times in a second for several years' regular work, making more than 200 million times altogether, but the iron retained its fibrous structure; and he thought axles could not be subject to so much vibration. When, therefore, he found that a connecting rod did not change its molecular texture, he must say there were good grounds for doubting that iron changes its state in axles.

Then with regard to the experiments made by Mr. McConnell with a view to ascertain where axles were most exposed to tension,

he could not quite agree with him, for he subjected the wheels and axles to a slow steadily increasing pressure, till he bent the axles in different positions. The results were correct as far as regarded the slow pressure on the flanches of the wheel under the circumstances of the experiments recorded by him, but they were not a faithful representation of what takes place in practice, for it would be found that when the wheels of a carriage jarred, a violent blow was inflicted on the rail, and the strain on the axle was totally distinct from a slow pressure.

He would refer to the experiments made some years ago by Mr. John Gray, on the Hull and Selby Railway, and which were published in the Engineers' and Architects' Journal, or the Mechanics' Magazine, to show how important is the element of time in the fracture of an axle. He took a round bar of iron 3 feet long and 2 inches diameter, and turned it down in the middle, to 1 inch in diameter for 2 inches in length. He then took another bar 1 inch in diameter uniformly throughout, and he tried the strength of these bars under *concussion* and not mere pressure. Now the severest point of strain would evidently be the middle of the bars where the diameter was the same in both, and consequently if weights were gradually and quietly laid on, the results would be alike in both bars; but when small weights were let fall on them, the bar 1 inch in diameter throughout its whole length was found to be much stronger than that which was in the main 2 inches and 1 in the middle. For as time is an element when the resistance of material is concerned, regarding the axle as elastic like a piece of india-rubber, the only particles that could yield to percussion from the falling weight were those between the shoulders in the part of the axle that was turned down, but in the case of the bar an inch in diameter throughout its whole length the whole of the particles would yield; the one being a good spring and the other a very bad one.

It therefore appeared to him that the experiments recorded by Mr. McConnell, though correct as regarded the position in which he put them, were not correct as regarded concussion. The axles rarely if ever broke in the middle, but generally at the end close to the boss of the wheel; because of the sudden change in the elasticity of the axle at that point; the portion of the axle

fixed within the boss of the wheel being very rigid whilst the rest remained elastic, which caused the vibrations to be suddenly checked at that point. No doubt the plan of weakening axles in the middle had done good because it made them spring, and in crank axles it relieved the strain in the cranked part.

Mr. HENRY SMITH suggested that in the case of bar-iron, the exterior portion had greater tenacity than the interior or under part; and the strength would be more than proportionately diminished where the exterior portion was cut through. He also referred to some experiments in which he had cold-hammered fibrous iron till it became crystalline, and the effect produced corresponded with the description given by Mr. McConnell of the fractured axles.

Mr. MCCONNELL observed, that he had met with several cases of broken axles in which a distinct annular space was observable all round the surface of fracture, that was quite short-grained and appeared changed into a crystalline texture, whilst the centre of the axle remained fibrous. He admitted that his experiments were only approximate, and that he had not put the strain in the natural way; but it was almost impossible to do so in consequence of the great trouble and expense that would have accompanied it; at the same time the results were proportionate in each case, and the accuracy of the experimental results had been confirmed by calculation. With regard to the axle fitting into the wheel, they now allowed only a very small shoulder, not exceeding a sixteenth of an inch, and this shoulder was not square but tapered, and the boss of the wheel was slightly coned to fit the shoulder.

Mr. COWPER did not believe that any axle which when broken proved to be crystalline had ever been fibrous in its character.

Mr. RAMSBOTTOM considered that a change took place in the axle from the effect of mere mechanical action, and his observations had tended to confirm him in that opinion. Some time ago he selected an axle which had not a very good form of journal, and the end broke off with two blows of a 12 lb. hammer. This axle had for three years been subject to a strain vertically, which was reversed at every revolution, and it came off with a crystalline

fracture. He then tried the part that had been within the boss of the wheel, which had not been subject to this great strain, and found the strength was very much greater than that of the journal, for it required 79 blows to break it off, and in that case the fracture was fibrous. A parallel case might be observed with reference to an ash stick which if doubled would break with a fibrous fracture; but if subjected to vibration, however slight, running through it a great number of times, it would break in a different mode. He thought the strain on a locomotive connecting rod was by no means so great for the sectional area as upon an axle journal; and the latter had two reversed strains for every revolution of the small wheels, but the connecting rod had only two for each revolution of the driving wheels.

The CHAIRMAN said, he was only desirous to put the members on their guard against being satisfied with less than incontestible evidence as to a molecular change in iron, for the subject was one of serious importance, and the breaking of an axle had on one occasion rendered it questionable whether or not the engineer and superintendent would have had a verdict of manslaughter returned against them. The investigation hence required the greatest caution; and in the present case there was not evidence to show that the axle was fibrous beforehand, but crystalline when it broke. He therefore wished the members of the Institution, connected as they were with the manufacture of iron, to pause before they arrived at the conclusion that iron is a substance liable to crystallize or to a molecular change from vibration. For his own part, he was now induced to look upon wrought-iron as literally elastic, like a piece of india-rubber; for in the case of the Britannia Tubular Bridge, where they had two 10 inch square chains or bars, each 100 feet in length, it was found that before the tube was raised the chains or bars stretched nearly 2 inches in length at each time of lifting, but resumed their original length when the strain was withdrawn; the same action being repeated every time the tube was lifted. He could therefore only regard these 10 inch bars of iron as analagous to a piece of india-rubber.

Mr. McCONNELL said, he had one specimen of an axle which he thought furnished nearly incontestible evidence of the truth of his position, that a change took place in the texture of the iron.

One portion of this axle was clearly fibrous iron, but the other end broke off as short as glass. The axle was taken and hammered under a steam hammer, then heated again and allowed to cool, after which they had to cut it nearly half through and to hammer it a long time before they could break it.

The CHAIRMAN remarked, that this was a case of converse reasoning; for it was an instance of a piece of crystalline iron being converted into fibrous iron. Iron when it was once heated and allowed to cool gradually, acquired a close and fine grain, but became neither crystalline nor fibrous; if cooled suddenly it acquired a crystalline grain, and if rolled while being cooled it became fibrous, but he did not think that it underwent any molecular change from mechanical action after it was cold.

Mr. HENRY SMITH observed, that throwing cold water upon hot journals did great injury by crystallizing that portion of the axle.

Mr. SLATE did not think that any change from a fibrous to a crystalline texture was produced in iron unless it were strained beyond the limit of its elasticity. Some of the pump rods in Staffordshire which had been in use for 18 or 20 years, were subject to a strain of 3½ tons per square inch; and a short time ago he had occasion to ascertain their actual performance with reference to this very question, and this not being considered conclusive, he had made a machine in which he put an inch square bar subjected to a constant strain of 5 tons, and an additional varying strain of 2½ tons, alternately raised and lowered by an eccentric 80 or 90 times per minute, and this motion was continued for so long a time that he considered it equal to the effect of 90 years' railway working, but no change whatever was perceptible; and therefore he was one of those who did not believe in a change from a fibrous to a crystalline structure in iron. He remembered a case where a question having arisen as to the manufacturers of a certain shaft, it was agreed to hammer it until it split as a means of discovering the nature of the manufacture of the shaft; the result was satisfactory; and the iron appeared still fibrous in texture.

Mr. HENRY SMITH promised to furnish some results of cold-hammering iron, at the next meeting.

The further consideration of the paper was then adjourned, and the Chairman said he wished that more of the Members had

been present at the meeting, and hoped they would attend and assist in the further discussion of the subject.

A vote of thanks was passed to Mr. McConnell for his communication.

The following paper by Mr. Sampson Lloyd of Wednesbury, was then read,

ON GEORGE NASMYTH'S PATENT GIRDERS AND FIRE-PROOF FLOORS.

The invention or peculiar construction of Girders, Fire-proof Flooring, Roofing, &c., which is the subject of the present paper, mainly consists of the adaptation of the "Bow and String" principle to the various objects required; and the method adopted in the construction of these works is explained by the accompanying Drawings and Models.

1.—The Invention as applied to Fire-proof Floors for Buildings.

The size and probable weight that the floor will be required to bear being ascertained, plate iron is taken of the required size and strength, and is bent in the form shown in Fig. 1 for the arch; and another plate is taken for the underside, which is turned up at each end as at A A, taking care that the space left between the turned up ends is of such a length as to retain the upper plate in its bent form. This bottom plate is not required to be of the width of the top plate, unless an even sur face is wanted, a strip of bar-iron or steel of the required strength will answer the purpose; neither is it requisite to have the top plate of the arch form, it may be bent as in Figs. 3 and 4 if desirable. When the top plate is bent and placed within the turned up ends of the bottom plates it is ready for fixing between the Wall Beams or Girders as in Fig. 5, and the space B B is then filled up with concrete or other substances, and covered as required. In all cases the under plate or tension bar should, to secure perfect safety, be of double the strength that is estimated to be requisite.

The strength will be in proportion to the weight to be placed on the top plate; the turned up ends act as the abutments of the upper plate, and each plate with its tension bars or plate becomes perfectly self-contained, and has not the slightest lateral pressure on the Beams or Girders on which it rests.

The entire weight which may ever be on such floor will act on the Wall Beams or Girders by a crushing force, which is the most favourable and perfectly free from any lateral action, so long as the tension bars or plates exist, see Fig. 6.

There is another great advantage in this construction, the bays or

spaces between the Walls or Girders may be wider than when brick arches are used and of less thickness; and further, if from any unforeseen cause one or more of the plates of the flooring were to give way, no other damage takes place to any other part of the floor, each plate being quite independent and in no other way bound to either Walls or Girders.

2.—The Application to Girders.

Girders in the first place may be considered simply as a Bow and String of the required lengths; on the Bow a second Arch is placed exactly corresponding with the outside of the Bow and extending to the point A A, see Fig. 8, having side plates B B, as also shown in Fig. 8. This forms a complete case over the Bow, and when the Girder is weighted, the arch being restrained from flattening or altering its shape by the case, the entire weight comes as a direct strain on the Tension Bar or String C C, Fig. 8. There is no fixture or attachment to the Tension Bar except at the ends, and the internal Bow or String is perfectly free from the case, as shown in the models.

Supposing a weight were suspended from the string of a Bow, the effect would be to raise the Bow as shown in Fig, 9; whereas if the same weight was applied to the Case covering the Bow as in Fig. 10, the effect would be to spread the strain in the most uniform manner all over the Bow, and transmit the whole weight into the chord or tension bar. For example: If a Girder 20 feet long had 20 tons placed on the centre, on this principle each foot of the Girder would bear one ton, and the Tension Bar would have to sustain 20 tons. In bridges as previously constructed it is customary to connect the Arch to the string as in Fig. 11, and there must be a tendency to deflect between every connecting plate. The same effect is produced where the Girders are formed by applying the pressure over the top of the Arch, Fig. 12; there is no uniform pressure or tension, whereas on this principle the weight can either be placed on the arch or suspended as in Fig. 13, which represents a Bridge and roadway; and in every case, if the load be placed in any varying position, the pressure and tension will be uniform. The rise of the Arch from the Chord has hitherto been made equal to one inch to the foot in length, and the Arch constructed by placing plates of cast or wrought-iron between angle-iron as in Fig. 14; but there are other methods as circumstances may require.

When the string or tension bars are too long for one plate it is proposed to use a series of links, such as are used in suspension bridges, and from the great length such chains can be formed there does not appear any precise limit to the span to which Girders or Bridges may be carried. The chains themselves can be used as an element of increased

strength, by laying them on each side of the roadway, which being suspended from the case covering the arch will be found to have the effect of giving rigidity.

The Roadways in Bridges are formed of a series of Cross Girders, see Fig. 15, and between them arched plates are laid as in floors, and then filled in with ballast as required. For Bridges on this principle there will not be required abutments of any kind, all the weight being downward.

Beams or Girders can be constructed of very great span, as the tensional action is the same; and to prevent the tendency to sag in the tension bars, light supports are easily placed under them attached to the bow or case as most convenient.

For Warehouses and large rooms where a clear space may be of consequence the advantage of this construction of Girder will be felt in a striking manner, there being no outward thrust on the walls, which may consequently be built thinner than is usual, and there is no necessity for stay bolts.

Girders can be made to sustain any given weight quite independent of the span, and with a peculiar advantage, viz., if a Girder was made to sustain 20 tons, the same Girder can be made to sustain 40 tons without making it one inch deeper; as to attain this object it is only necessary to increase the width of the case and insert one or two additional arches and tension bars as may be required, thus only making the Girder wider, which in buildings is often of great importance, see Fig. 16.

3.—The Application to Roofs.

When the patent construction is applied to Roofing the extreme lightness will be the chief feature. The bow and tension bar form the principal, and plate iron, timber, or any other suitable material is employed for covering the saddle or archcase, see Fig. 19.

4.—The Application to Bridges.

This invention is peculiarly adapted for Bridges, as previously stated; but there are many advantages not mentioned, one or two of which may be alluded to. When the foundations on which the pier of a bridge rest are bad, the freedom from lateral pressure is of great importance; also in Viaducts where simple pillars or piers are built. In bridges of wide spans the outside Girder can be made of sufficient depth by making the arch of the Girder and case serve for the parapet, see Fig. 20.

5.—Dock Gates and Caissons.

The principle is applicable to the construction of Dock Gates and Caissons, particularly to such as are of large dimensions. In such con-

structions the tension bar may be in the centre with an arch and case on each side as in Fig. 17, capable of resisting equally the weight of water on either side.

6.—Jetties or Piers.

Jetties or Piers may be advantageously constructed on this principle, and may be made to extend a considerable distance for a comparatively small cost. For instance, a Foot Bridge or Pier as in Fig. 18, may be constructed to rest on the land in the usual way on the one end, and on a barge at the other, rising and falling with the water.

In conclusion, it may be observed the advantages attained by this invention are, that in *Fire-proof Buildings* the walls are free from lateral thrust; the floors may be made thinner, and the number of stories safely increased; rooms of a large size may be constructed without any pillars or supports except the outer walls, at a much less cost than in the ordinary construction. Floors on this construction are fire-proof, are easily made to sustain any given weight or to support an increased weight, and are not liable to be destroyed by decay or vermin, and no part of the floor giving way causes an extra strain on the other parts, as the whole floor is formed of self-contained and independent parts.

In *Girders*, by the combination of wrought-iron, cast-iron, and steel, their strength, form, or weight may be adapted to meet almost all circumstances; and larger spans in *Bridges*, &c., can be adopted with a much less consumption of materials than in other constructions, besides taking into consideration the slight support required from the absence of lateral thrust.

Many experiments have been made on a larger scale than the models now laid before the meeting; and it has been ascertained that the comparative strength of these Girders, when compared with cast-iron, is as 7 to 28, or four times as strong: that is, a girder that would weigh 4 tons in cast-iron, to carry a certain weight, can be constructed to carry the same weight on this principle and will only weigh 1 ton.

Mr. Lloyd regretted that Mr. Nasmyth was not present, as he would have been much better prepared to explain the principle of the girder, and answer any objections that might be raised; Mr. Nasmyth had intended to be present at the meeting, but was unexpectedly prevented from attending.

The Chairman observed, that the bar of wrought-iron which was employed as an arch in the girder, was not capable of sustaining much compression without buckling; and he could not understand why wrought-iron was introduced into arches, when the arch was the best possible form for the adoption of cast-iron.

Mr. LLOYD replied, that though cast-iron would bear a greater compression, the introduction of wrought-iron facilitated the distribution of the pressure over the whole girder. The longitudinal box that was placed over the arched rib distributed the pressure over the rib, and prevented it from buckling, and the whole strain was conveyed to the tension bar.

Mr. COWPER thought the proposed construction involved the employment of a large quantity of metal which was of no possible service; particularly the metal in the ends of the box of the girder, which did not appear to give any addition to the strength. He should be glad to know the results of experiments on the comparative strength of the girder; and he much doubted the applicability of the plan to girder bridges. He suggested that it would be better to make the wrought-iron box in the form of an arch and put it in the place of the arched rib, which he considered would give the same strength with much less material.

The CHAIRMAN remarked, that he did not see where the principle of the bow and string girder, differed from that of the girder bridges erected on the North Western Railway at Camden Town and Buckby.

Mr. HENDERSON thought the principle was the same only adopting wrought-iron instead of cast-iron for the arched rib, and that cast-iron was much preferable for the purpose; he believed the introduction of wrought-iron had been caused by the public apprehension with reference to cast-iron girders of large span. It appeared to him that the plan proposed for distributing the weight upon the girder, by covering it with a wrought-iron box, was objectionable both in theory and practice, and involved a waste of material; and he considered the most economical and scientific way of doing it was by the introduction of diagonal side-pieces between the arched rib and the tie, instead of continuous side plates.

The CHAIRMAN agreed with the suggestion of Mr. Cowper that it would be preferable to combine together the box and the rib; but instead of putting the material in the form of an arch, he thought it would be better to carry it straight along the top. The upper portion was entirely subjected to compression and the lower portion to tension, and when the parallel form was adopted the compression and tension acted by the same leverage at all

parts of the girder; but when thrown into the arch form this leverage was so much diminished towards the ends, on account of diminished depth of the girder, that the thickness would require increasing there to obtain sufficient resistance, which involved an increase in the quantity of material employed.

Mr. Cowper thought this increase would be slight, compared with the saving of material effected at the ends by adopting the arched form instead of the straight top. In the parallel box-girder, formed with side-plates, the strain passed down obliquely through the side-plates to the lower part of the girder at each end, and the plates were required to be thicker at that part; but he thought the better plan was to place the material in the direction of this strain by making the box-girder in the form of an arch and tying the ends together by the tension bars.

Mr. Slate was of opinion, that a cast-iron rib with a wrought-iron tie, was the most economical and efficacious application for the girders of railway bridges.

The Chairman remarked, that with some variation the proposed plan might be satisfactorily adopted for supporting the floors of warehouses, but he thought there would be great difficulties in applying it to bridges of large span.

A vote of thanks was then passed to Mr. Lloyd for his communication.

The Chairman announced that the Ballot lists had been opened by the Committee appointed for the purpose, and that the following new Members were elected.

Members.

Mr. Humphrey Chamberlain, Worcester,
Mr. William Johnson, Glasgow,
Mr. Robert Morrison, Newcastle-on-Tyne.

A vote of thanks was passed to the Chairman, and the proceedings terminated.

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